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Hip Flexibility and Its Relationship to Hip Discomfort in Female Ballet Dancers

by

Kristina Kirstie Covlin ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of
the requirements for the degree of Master of Arts

Faculty of Physical Education and Recreation

Edmonton, Alberta

Spring, 1996

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled Hip Flexibility and Its Relationship to Hip Discomfort in Female Ballet Dancers submitted by Kristina Kirstie Covlin in partial fulfillment of the requirements for the degree of Master of Arts.

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January 29th, 1996

ABSTRACT

The purpose of this study was to identify those individuals in the female ballet dancer population who may be predisposed to injuries at the hip. The relationship between hip flexibility and injuries was examined through the use of the Leighton Flexometer, Visual Analogue Scale (VAS), and the McGill Pain Questionnaire (MPQ). This study has shown that dancers who are highly inflexible are at an increased risk for injuries at the hip. Ballet dancers who are highly flexible were not shown to be at an increased risk when compared to the moderately flexible dancers, in fact, the highly flexible dancers were the least likely to experience discomfort and least likely to have discomfort affect their dancing. Internal rotation and adduction at the hip were shown to have an inverse relationship with the other flexibility ranges. As internal rotation and adduction decreased, pain in the hip region increased.

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Many thanks to my committee members, Dr. David Magee and Dr. Sandy O'Brien Cousins, for their many helpful comments and assistance during the writing of this thesis. Special thanks to Dr. Marsha Padfield, Committee Chair, who has guided my throughout my undergraduate and graduate student years.

DEDICATION

To my family, who always encouraged me to keep going and stay on track.

And to Randy, for keeping me sane throughout this process.

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INTRODUCTION

The life of a classical ballet dancer is full of physical, artistic and aesthetic requirements that are demanding and unyielding. Maximum outward rotation at the hip, called "turn out", is required as well as extreme hip flexion to a level well above shoulder height. These demands put immense anatomical and physiological stress on dancers.

The evolution of ballet technique has ensured development of a large degree of outward rotation of the leg which allowed for a more aesthetically pleasing line of the leg, smooth traveling sideways on the stage, and allowed the leg to abduct, flex, and extend in a greater range of motion. In the ballet world, "the more turnout the better". However, when this range of hip motion is considered in relation to the anatomy of the hip, it predisposes the dancer to injury (Kushner et al, 1990).

The hip joint is a multiaxial ball and socket joint (Magee, 1992) formed by the head of the femur and the acetabulum; the joining of the ishium, ilium, and the pubic bone form the socket. The fovea on the head of the femur is attached to the acetabulum by the ligamentum teres (Calais-Germian, 1993). The labrum attaches to the lip of the acetabulum and is reinforced by the transverse acetabular ligament. Because of the bony structure, pure abduction is limited by the contact of the greater trochanter of the femur with the pelvis. "The need for lateral rotation has sound anatomical basis since it allows greater hip abduction without impingement of the greater trochanter" (Reid, 1988).

Kushner, Saboe, Reid, Penrose, and Grace (1990) confirmed that external rotation is needed to achieve the high extensions demanded in ballet. However, this emphasis is not without cost. Studies by Miller et al (1975), Micheli et al, (1984), Meinel and Atwater (1988) found that the insistence on the perfect one hundred and eighty degree turnout may contribute to the lower limb problems in dancers who are unable to achieve adequate hip range of motion. Without sufficient external rotation of the hips, significant stresses are placed on the knees and ankles (Reid, 1988, Ende & Wickstrom, 1982, Dunn, 1965, Gelabert, 1980, Hamilton, 1982). Insufficient hip flexibility and injury have been shown to cause a host of injuries to the back (Reid, 1988, Howse and Hancock, 1988). Stresses are also placed on the hip itself. The tendons and musculature surrounding the hip joint are arranged in spiraling fashion. As the leg is externally rotated the ligaments, because of their spiral arrangement at the hip, unwind and as the leg rotates internally, they tighten. Because of this, the hip is less stable in the externally rotated position, placing great stress on the soft tissue around the joint (Personal Communication, Dr. Robert Steadward, December 7th, 1994). The dancer however must cultivate this external rotation in order to achieve the greatest possible range of movement, both statically and dynamically. Therefore, because of this spiral arrangement of the tendons and muscles, there is great anatomical pressure on the soft tissues surrounding the hip (Personal Communication, Dr. Robert Steadward, December 7th, 1994).

In the ballet world, hip range of motion is central to the highly flexible physique admired and demanded by artistic directors, choreographers, and audiences. Any factor which may limit hip range of motion is of major concern to the dancer. As insufficient hip flexibility may cause injuries to the back and lower extremities (Reid, 1987, Howse and Hancock, 1988), it is important to encourage not only correct technique but also maximization of hip flexibility within the dancer's anatomical limitations.

Little evidence exists to date to inform us as to which dancers are prone to injury. Is there a physical flexibility profile for dancers which increases the potential for injury? Previous studies have examined hip flexibility patterns in dancers (Clippenger-Robertson, 1990, Miller et al, 1993). A extension of these studies would be to look at the relationship of hip flexibility to the incidence of injuries at the hip. The folk maxim within the dance world is "the more flexible the better", but flexibility at either extreme may contribute to injury (Bauman, 1982).

MARTYR SYNDROME

Added to concerns about anatomical stress is the stoic tolerance of dancers to ignore pain and injury. "To introduce factors that assist in prevention and treatment of injuries is not easy, since the art of ballet is steeped in folklore" (Reid, 1988). The art of ballet is highly dependent on tradition, and unfortunately a mistrust of the medical profession by dancers is part of ballet's history. According to Reynolds, dancers were in the past treated as "postadolescents indulging in a transient profession of dubious merit, willing to embrace any treatment . . . that promised to improve whatever they thought was wrong with them. The ultimate cure was always to just stop dancing, they were never taken seriously." (Reynolds, 1993) Ballet dancers are notorious for dancing through pain and injury. " It is implied that dancers should not complain about such things (as injury and pain) and if they are not ready to sacrifice their health to the wonderful art, they should not be dancers"(Reid, 1988,) This "martyr syndrome" makes the inquiry into any injury difficult with this population. "Injury" is therefore an inadvisable term to use in a research protocol. Evaluation of hip injuries is also tenuous due to the frequent lack of medical evaluation. Many dancers are unaware of the specific injury - they only know that it hurts. Thus the relationship between hip flexibility and pain is a more viable topic, especially since pain measurement is possible through subjective assessment. The Visual Analogue Scale (VAS) and the McGill Pain Questionnaire (MPQ) have been widely used in the study of pain and have been recognized for their validity and reliability (Scott & Huskinsson, 1979, Melzack, 1975). A study examining pain experiences would therefore be more liable to yield useful information appropriate than a study focusing on injury.

STATEMENT OF THE PROBLEM

Although research has examined hip flexibility in dancers, little has been done to determine what, if any, relationship exists between hip flexibility and hip pain a dancer may experience. Dancers must be flexible to succeed in their art. It is also known that most dancers experience pain and injury. It is therefore important to determine how these hip flexibility and hip pain relate. It is hypothesized that there is a relationship between hip flexibility and hip pain. If a relationship exists, this information can be applied to training methods. By identifying the ideal range of flexibility, dance professionals can adapt training to prevent or minimize injuries.

OBJECTIVES OF THE STUDY

One of the challenges in dance research is to identify and assess those individuals who might be predisposed to injuries related to limited or excessive flexibility. The objective of this study was to assess the relationship between hip flexibility and pain experienced by female ballet dancers. It was important in the prevention of injuries that this relationship be studied to improve methods of training. Flexibility was determined through the passive and active range of motion using measurements of flexion, extension, abduction, adduction, internal rotation and external rotation at the hip. Discomfort was assessed with the use of the Visual Analogue Scale (VAS) and McGill Pain Questionnaire (MPQ).

RESEARCH HYPOTHESIS

The hypotheses of this study were:

1. That subjects who are highly inflexible or highly flexible would experience more pain..

2. That as range of motion for external rotation, flexion, flexion with external rotation, abduction, abduction with external rotation and extension increased, range of motion for internal rotation and adduction would decrease (Kushner et al, 1990).

3. There will be a positive correlation between the balletic ranges of motion, external rotation, flexion, flexion with external rotation, abduction, abduction with external rotation and extension, and the years of training.

4. There will be a negative correlation between the non balletic ranges of motion, adduction and internal rotation, and the years of training.

5. There will be positive correlations found between each of the balletic ranges of motion and between each of the non balletic ranges of motion (Table 1).

6. As internal rotation and adduction range of motion decreased, hip discomfort would increase.

7. As the bi-iliac width increased, flexibility would decrease.

8. As bi-iliac width increased and flexibility decreased, pain in the hip region would increase.

TABLE 1 - HYPOTHESIS #5 POSITIVE CORRELATIONS

BALLETIC RANGES	
External Rotation	Flexion
External Rotation	Flexion with External Rotation
External Rotation	Abduction with External Rotation
External Rotation	Extension
Abduction with External Rotation	Flexion
Abduction with External Rotation	Extension
Abduction with External Rotation	Flexion with External Rotation
Flexion with External Rotation	Extension
NON BALLETIC RANGES	
Adduction	Internal Rotation

DEFINITIONS:

For the purposes of this study, the following terms were defined as:

1. Flexibility was the range of motion around a joint (Miller et al, 1993). At the hip the specific movements were flexion, extension, abduction, adduction, external rotation and internal rotation (LeGreci-Mangini, 1994).

2. Discomfort and pain was used interchangeably to mean the experience of unpleasant, uncomfortable, or troubling sensations. During the study, it will be assumed that these sensations signified injury.

3. Grande Battement devant - a movement in dancing where the leg is lifted to the front, involving both flexion and external rotation at the hip and the knee remains extended throughout the entire range of motion (Figure 1).

4. Grande Battement side - a movement in dancing in which the leg is lifted to the side. This involves abduction, external rotation, and a small degree of flexion at the hip. The knee remains extended throughout the entire range of motion (Figure 2).

5. Ronde de Jambe en l'air - When the leg is moved from the devant/front position (external rotation and flexion) to the side position (abduction, external rotation, and slight flexion). This movement can also go from the side to the back, called arabesque (Figure 3) (hyperextension and external rotation, as well as extension at the spine). The movements can also be reversed. The knee remains extended throughout the entire movement.

6. Bi-iliac width was defined as the distance, in centimeters, between the Anterior Superior Iliac Spines (ASIS).

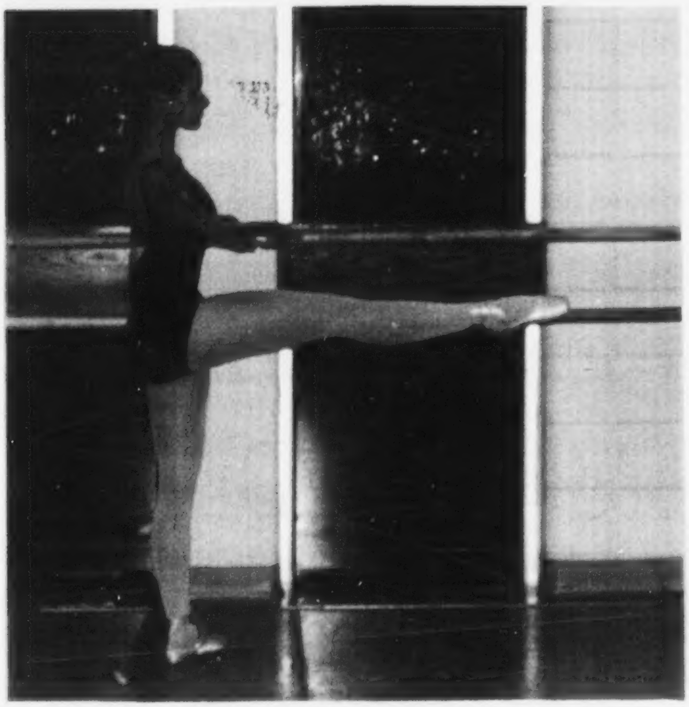

Figure 1. Devant Position

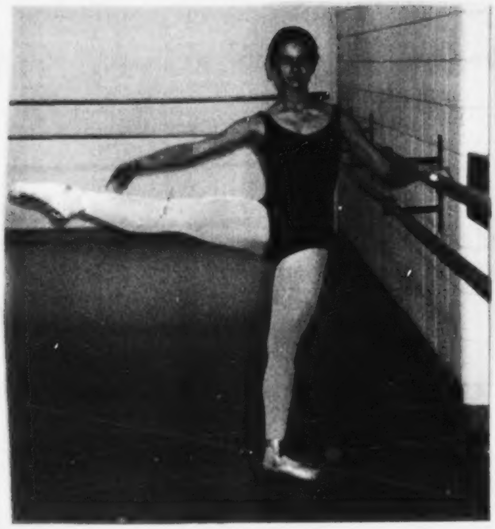

Figure 2 - Second Position

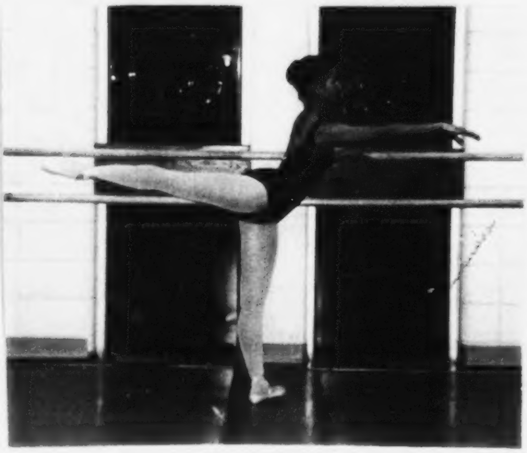

Figure 3 - Derriere Position

REVIEW OF LITERATURE

Research relating to hip injury and hip pain encompasses many areas. Previous research has been completed on flexibility, dance injuries, and pain measurement (Kushner et al, 1990, Clippenger Robertson, 1990, Knapik et al, 1992, and Carlsson, 1983). Important work relating to ballet has been done by medical professionals such as Reid (1988), Howse and Hancock (1988) and Ryan and Stephans (1988), all of whom have devoted time in the application of athletic medical care to dance.

FLEXIBILITY

Flexibility is an important component of fitness. It is a complex factor and researchers now realize it requires complex measurement, rather than simple measures previously used (Hubley-Kozey, 1991). Flexibility is not a general characteristic, but is joint and joint action specific (Hubley-Kozey, 1991). Clippenger -Robertson (1990) agrees, stating that flexibility is also direction specific. "It has been hypothesized that flexibility characteristics contribute to the prevention of injuries, the rehabilitation of injuries, and the performance of various skills" (Koslow, 1987). It has been assumed that more flexible athletes are the less likely they are to be injured (Klafs and Arnheim, 1973, cited in Knapik, 1992).

For the dancer, flexibility has many functions. Clippenger-Robertson (1990) cited the extreme range of motion or flexibility which was frequently utilized as one of the unique characteristics of dance. For some forms of dance, particularly ballet, this extreme flexibility is a prerequisite for success (Clippenger-Robertson, 1990). Miller et al (1993) cited poor flexibility as a contributing factor to poor performance and injuries. Koslow (1987) stated that flexibility characteristics contributed to the prevention of injuries, the rehabilitation of injuries, and the performance of various physical skills. This implies that not only is the degree of flexibility important, but also the type and function of the flexibility. Further, Koslow believes that degrees of flexibility appear to be related to habitual movement patterns, which would support the unique flexibility in dancers as required by the art and practice of ballet.

Ekstrand and Gilquist (1982) state that a degree of range of motion may help prevent injury to a muscle or tendon. But what amount of flexibility is optimum when the individual is subjected to the high demands of ballet? The competitive nature of dance training aggressively focuses on the enhancement of one's flexibility, maximizing and trying to exceed an individual's genetic endowment (Clanin, 1993). As a result, dancers are constantly pushing themselves and being pushed by others to work at the extreme end of their anatomical capabilities. Clippenger-Robertson (1990) recognizes the importance of balancing increased flexibility with increased muscular strength. "Most important is the influence of flexibility of technique. Inadequate flexibility can lead to compensations that can be injurious and aesthetically undesirable" (Clippenger-Robertson, 1990, p.2)

Knapik, Jones, Bauman, and Harris (1992) examined the relationship between strength, flexibility, and athletic injuries by reviewing the literature. "It has been commonly observed that participants most susceptible to injuries tend to exhibit range of motion close to either extreme of a flexibility continuum" (Knapik et al, 1992). There appears to be as great a risk in being extremely flexible as there is in being inflexible. Flexibility is defined by the Knapik et al (1992) as the amount of movement of a joint through its normal planes of motion. The amount of flexibility affects the type of injury which may be sustained. For example, muscle strains may be more likely to occur in athletes who lack flexibility, whereas highly flexible athletes may be prone to sprains or dislocations (Knapik et al, 1992). Bauman et al (1982) looked at hip flexion and extension and found a U shaped statistical pattern where subjects who were at either extreme of flexibility were more likely to suffer lower extremity injuries. Cowan et al (1988) found similar results with hip and lower back flexibility. Liemohn (1978) found injured subjects had less hip flexibility (movement not specified). Clanin (1993) felt it was important to identify a "safe" range of ligament laxity and musculotendinous extensibility. Dancers frequently sustain overuse injuries of the lower extremities (Washington, 1978, Quirk, 1983) and poor flexibility may predispose the dancer to and hinder recovery from injuries (Miller et al, 1993).

INJURIES AND FLEXIBILITY

Knapik et al (1992) found that the influence of past injuries on current flexibility was unclear. Kirby et al (1981) found gymnasts reporting musculoskeletal symptoms in the hip area had less hip extension flexibility on the left, but not on the right.

The issue of hypermobility in dancers joints is controversial. Grahame and Jenkins (1972) found that dancers tended to be hypermobile, significant because hypermobile individuals are prone to musculoskeletal injuries (Scott et al, 1979). However, when Klemp and Learmouth studied dance injuries in a professional ballet company over a ten year period, they found evidence to the contrary. They found that dancers were only hypermobile in the specifically trained movements which ballet requires, a trained response to the demands of the art.

THE IMPORTANCE OF THE HIP TO THE DANCER

The hip area is of extreme importance to the dancer. "Together with the pelvis, the hip is the focal point of the dancer's concentration" (Kushner et al, 1990). Flexibility at the hip in dancers involves a greater range of motion than that found in the normal population or even in an athletic population.

Ninety degrees of outward rotation is considered adequate in the athletic population (Clippenger-Robertson, 1990). Fairbank et al (1984) used goniometer and jig measurements in their study of hip external rotation in youth. Female subjects aged thirteen to seventeen were found to have external rotation of 63 degrees (+/- 9) with the knee flexed at ninety degrees. Allander et al (1974) found that the normal range of motion for passive hip external rotation with the hip flexed at ninety degrees to be between 64-81 degrees. Dancers, however, should have a minimum of 120 degrees, ideally approaching 160 degrees (Clippenger-Robertson, 1990). Hip external rotation may be limited by musculotendinous factors, particularly the internal rotators, but also by ligamentous, capsular, and bony constraints.

Clippenger-Robertson (1990) stressed the importance of adequate external rotation or turn out for injury prevention. Common compensations for lack of turnout include: tilting the top of the pelvis, arching the lower back (which relaxes the iliofemoral ligament), or external rotation of the tibia relative to the femur or ankle, rotation of the ankle and pronation of the foot. A dancer must greatly exceed the range which is acceptable in normal populations (90 degrees), especially in classical ballet where one hundred and eighty degrees is considered optimum in both first and fifth positions of the feet (Clippenger-Robertson, 1990). Thomasen (1982) recommend a minimum of sixty degrees (for each side) of external rotation in order to pursue a career in classical ballet. Clippenger-Robertson (1990) has focused on static flexibility (passive range of motion) but acknowledged the importance of dynamic flexibility (active range of motion). She stated that dynamic flexibility was complex, including adequate muscular strength and appropriate muscular activation patterns.

Hardaker et al (1987) examined students at the American Dance Festival. Their goal was to study the pathomechanics (the origin) of injury and determine how and why injuries occurred. From this data, the researchers hoped to better understand the implications for injury prevention. Hardaker et al (1987) found that dancers who have poor turnout at the hip might "cheat" by attempting to achieve greater external rotation at either the knee, ankle, or foot which, in turn, may lead to excessive external rotational force at the tibia. These events can lead to a wide variety of injuries, such as medial injuries to the knee.

Ideally turnout is achieved through external rotation of the hip, but Ende and Wickstrom (1982) conceded that a dancer who could not do so would incorrectly compensate by gripping the floor with the feet. Ende and Wickstrom (1982) cite external rotation at the hip which is not well executed as the cause for a large number of injuries in the lower extremities. Kushner et al (1990) examined the relationship between hip external rotation and hip abduction. Their aim was to determine the amount of external rotation required for the maximal abduction in ballet dancers. They used a goniometer to measure the abduction and a flexometer to control the amount of external rotation. In weight bearing, many dancers compensate for insufficient hip motion by rotation at the knees, eversion of the heels, pronation of the feet, and lordosis of the lumbar spine. (Hardaker and Erickson, 1986, Lawson, 1984, Peterson, 1986, Kushner et al, 1990). External rotation is considered crucial to achieve maximal abduction.

If a dancer has insufficient range of turnout or faulty technique, these factors may predispose the dancer to injury. Kushner et al (1990) cited a lack of research determining the ideal functional hip range for ballet. They found no information regarding the point at which additional external hip rotation effectively increases the amount of obtainable hip abduction. Kushner et al (1990) measured abduction with increasing amounts of external rotation. A goniometer was used to measure the amount of abduction, while a Leighton flexometer was used to measure set degrees of hip rotation. The Leighton flexometer was chosen because of its high reliability (Hsieh et al, 1983, Leighton, 1955, Kushner et al, 1990). The hip was fully passively abducted with the dancer lying supine. Hip flexion was prevented until the maximum abduction was reached, and then twenty degrees (approximately) of flexion was allowed so that the dancer could reach his/her maximal abduction (which was impossible without the flexion).

Kushner et al (1990) discussed at length the importance of external rotation to the abduction range of motion in dancers. External rotation allowed the dancer to abduct the leg to a greatly increased range by delaying contact of the greater trochanter with the acetabulum. Further, slight flexion allows the structures around the hip joint to relax. When these factors are added to the tilt of the pelvis toward the opposite side that occurs with external rotation, extreme range of motion can occur (Kushner et al, 1990). The authors recommended that further research not allow any flexion to obtain pure abduction movements. However, this concept can be disputed. If the true functional flexibility of the dancer includes flexion, then a combined assessment is important for researchers to consider.

Kushner et al (1990) found a significant positive correlation between external rotation and abduction ($p<0.05$); as external rotation increases, so does abduction. Increased abduction was found on the non-dominant side, possibly due to the stronger and tighter extremities on the dominant side (Kushner et al, 1990). The results of the study are summarized below.

TABLE 2 - Kushner et al (1990) Results

External Rotation	Abduction
0 degrees	67-68 degrees
60 degrees	94-97 degrees
70 degrees	97-99 degrees
80 degrees	107-115 degrees
90 degrees	116-123 degrees

Internal rotation and adduction movements are frequently less flexible in dancers than in other athletes or the general population. The older the dancer the more exaggerated this trend. Kushner et al (1990) believed that the influence of external rotation on abduction ceased at the point at which flexion had to be allowed to achieve further elevation.

Miller et al (1993) attempted to establish normative ranges of joint motion in advanced level ballet dancers to aid in the prevention and treatment of injuries as well as promote optimal performance. Their study of forty-four dancers used a goniometer to measure active hip flexion and extension. Ballet requires a great deal of flexibility and loss of range of motion may precipitate future and/or additional injuries (Miller et al, 1993). A dancer who is unable to achieve the proper "line" or degrees of range of movement required will not be able to survive in the highly competitive field.

It is important to note in regards to the Miller et al (1993) study that active range of motion (AROM) is made up of both flexibility and strength, so a reduction in AROM may indicate a deficit in either. Dancers have a greater active ROM when compared to standard values for normal population and athletes, however the range is less than those found passively by Reid et al (1987). Active ROM will be important in understanding the functional ability of the dancer to use their flexibility.

INJURIES IN DANCERS

Dance injuries are most often the result of faulty technique (Howse & Hancock, 1988). Technical errors are often the result of compensatory and/or maladaptive movement patterns secondary to anatomical limitations (Bachrach, 1993). Ende and Wickstrom (1982) stated that "the dancer suffers pain that could be avoided" through inappropriate or ineffective training methods and lack of medical care. "Only in the last five years has medical care for ballet associated injuries received more than perfunctory professional interest in the United States" (Ende & Wickstrom, 1982). English and Russian dancers have long been exposed to rehabilitative care and injury clinics resulting in a three-fold decrease in injuries (Volkov & Badnin, 1970, Ende & Wickstrom, 1982).

In most forms of dance, the hip is the fourth most injured site after the knee, ankle, and foot (Horosko, 1987). Problems at the hip form about ten percent of injuries, with studies ranging from seven to fourteen percent (Reid, 1988). Rovere et al (1983), in their study of 218 theatrical dancers, found that 14.2% of injuries occurred at the hip. Of injuries which required the dancer to abstain from work, hip tendonitis required the most average days off dancing (6.9). Washington (1978) in his classic study of theatrical dance injuries found that 7% were hip injuries. However, it may be possible that problems at the hip are responsible for some of the other injuries.

Garrick and Requa (1993) studied the incidence of injuries in dancers. While they found that hip injuries made up 5.8% of the total number of injuries, it is important to realize that this injury occurred in 26% of the dancers surveyed. This is a significant percentage of dancers suffering from hip related problems. Other research focusing on pain in the hip region suggests that up to 65% of dancers experience hip discomfort during their training (Covlin, 1992). Solomon and Micheli (1986) found hip injuries to be 11.4% of the total number of injuries. However, the authors noted that the incidence of hip injuries in ballet dancers was higher than that of the general dance population. Although other parts of the body are injured in dance with greater frequency than the hip, the hip injuries are often more serious and difficult to treat (Micheli, 1988). Many of these injuries (to the hip) are preventable if recognized early and given preventive exercises and technique corrections (Micheli, 1988).

Several studies have suggested that right/left imbalances in hip flexibility may increase the risk of muscle strains and sprains (Knapik et al, 1992). Merrifield and Cowan (1973) found that subjects were 5.6 times more likely to suffer hip adductor strains if they had a hip adductor flexibility imbalance of 4 degrees or more. Knapik (1992) found that athletes were 2.6 times more likely to suffer injuries if they had a hip adductor flexibility imbalance of 15% or more. Agre and Baxter (1987) found that 75% of subjects with a right/left imbalance of 6 degrees or more were injured, while those with less than 6 degrees had no injuries.

Washington (1978) stated that the etiology of dance injuries was multifactoral and that the rotated position of the lower extremities was an important cause of injury. Other authors, Ende and Wickstrom (1982) as well as Reid, (1987) and Howse and Hancock (1988) have noted that problems associated with turnout led to injuries in the back, legs and feet. The hip area affected the trunk and lower extremities. The anatomical fact that the hip connects the trunk/pelvis to the lower extremity accounts for the widespread effect a problem at the hip can produce (Howse & Silva, 1985).

TYPES OF HIP INJURIES IN DANCERS

Chronic injuries to the hip are produced by incorrect use of the muscles around the hip (Howse & Silva, 1985). Microtraumatic causes of pain in the hip area are overuse, faulty technique, incorrect alignment, use of a particular style or movement to the exclusion of balanced work, gradual deterioration of the joints and insufficient warm-up (Horosko, 1987). Injuries to the hip include stress fractures, clicking and snapping, gluteus medius bursitis, iliopsoas bursitis and osteoarthritis (Ende & Wickstrom, 1982).

Frequently, the dancer complains of clicking and snapping in the hip (Ende & Wickstrom, 1982). While the snapping hip may exist at two different sites without pain, it has been Micheli's (1988) experience that if snapping is allowed to persist, both sites will usually become painful and will limit dancing. The "internal" click occurs when the iliofemoral ligament slides over the head of the femur or the "external" click when the iliotibial tract slides over the greater trochanter (Howse & Hancock, 1988, Reid, 1987, Ende & Wickstrom, 1982). The internal (inner or medial) snapping was formerly thought to be due to a subluxation (partial dislocation) of the hip, but is now thought to be the iliopsoas tendon sliding over the neck of the femur (Micheli, 1988). This explanation of the internal click is slightly different than that offered by Howse and Hancock (1988). According to Howse and Hancock (1988) the clicking hip is usually of no significance. Dancers with a narrow bi-iliac width are predisposed to this condition (Jacobs & Young, 1978). Jacobs and Young (1978) state the importance of strengthening the adductors and medial rotators to alleviate the problem. Stretching of the iliotibial band can reduce the external clicking. Constant snapping at the hip can lead to irritation, swelling, and tendonitis (Horosko, 1987, Howse & Hancock, 1988). Treatment involves the avoidance of movements which cause the click - grande plie, developes, ronde de jambes, and jumping. These steps are the cornerstones of ballet technique, so a dancer must not dance at all in order to avoid these movements.

Bursitis is also frequently reported, according to Ende and Wickstrom (1982) which can occur deep to the insertion of gluteus medius or superficial to the iliopsoas tendon. It is caused by pulling too hard with the gluteal muscle when turning out and tucking under of the buttocks and the sacrum, and "sitting in the hip". Conditions that limit turnout include gluteal bursitis (Howse & Silva, 1985). Gluteus medius bursitis produces pain on abduction and internal rotation, whereas bursitis of the iliopsoas tendon produces pain upon active and passive flexion of the hip (Ende & Wickstrom, 1982).

Ende and Wickstrom (1982) believe that degenerative arthritis is more frequent in older dancers than in the general population. However, more recent work by Reid (1988) disputes this idea. "There is very little to substantiate the claim that osteoarthritis is more prevalent in dancers" (Reid, 1988). The excellent range of motion at the hip in older dancers may in fact provide some protection against earlier degenerative changes. Reid (1988) feels that symptomatic degenerative changes of the hip are not more frequent in dancers. "The best approach to the problem of dance injuries is in the area of prevention" (Stojanovic et al, 1963). Howse cites poor technique and alignment, such as not keeping the knees over the toes, as the greatest cause of injury (Howse and Hancock, 1988) and this must be corrected in order to properly rehabilitate the dancer.

PROBLEMS WITH RESEARCH FOCUSING ON DANCE INJURIES

Dancers in Klemp and Learmouth's (1992) study reported a mean of 5.5 injuries within the ten years. Unfortunately, the researchers acquired their injury data from the medical reports from worker's compensation which ignores that fact that many dancers may have had injuries for which they did not seek medical treatment or workers compensation. It is well documented that dancers frequently do not seek help from the medical profession and it is probable that more injuries occurred than were reported (Gordon, 1983, Reid, 1988).

Kushner et al (1990) studied dancers without a "history of hip pain which required treatment of a day off dancing within the 6 months prior to testing" (p. 287). However, this does not mean that they did not have any pain. Dancers in Miller et al's study were uninjured. However, the authors do not clarify the criterion for "uninjured". Miller et al (1993) suggest that further study should focus on a possible correlation between flexibility and rate of injury. But again, they do not define injury. It is known that dancers avoid medical treatment and dance with pain. Dancers avoid the use of the word injury. Therefore, reliable data on "injury" is very difficult to obtain. It is important to realize that research on "hip pain" has shown that the incidence of discomfort may be much higher than that of "injury" (Covlin, 1992).

PSYCHOLOGY OF THE DANCER AND ITS RELATIONSHIP TO INJURIES

Hamilton et al (1989) studied elite ballet dancers who were principals and soloists of leading ballet companies. These dancers ranged in age from twenty-two to forty-four. They found that psychological and physical factors contributed to the incidence of injury. The researchers found that injured dancers tended to be over-achievers. This may be due, in part, to the demand that dancers continually compete with themselves, constantly push to improve, and can never be satisfied with their performance. Hamilton et al's (1989) study suggests that the qualities necessary to become a dancer, a continual drive towards perfection, can also lead to chronic injuries if taken to the extreme. A better understanding of the psychological correlates of physical injury may provide a key to survival in the art form.

UNIQUE INCIDENCES OF HIP PAIN IN DANCERS

Two studies have reported subjects with unusual episodes of pain related to flexibility. Miller et al (1993) reported that there were two subjects in their study with previous tendonitis in their hips. Interestingly, these two dancers had the greatest range of hip flexion both in the neutral and externally rotated positions. Kushner et al (1990) reported three female subjects with acute sharp pain during passive motion at the limit of abduction in 70-90 degrees of rotation. Immediate internal rotation instantly resolved this pain which was confirmed to occur during dancing. Causes may include the iliopsoas slipping over an osseous ridge on the lesser trochanter or the iliofemoral ligament snapping over the femoral head (Kushner et al, 1990). Abduction movement performed with hip flexion may prevent this problem from occurring.

MEASUREMENT OF PAIN

Physiologists have researched the specific measurement of pain through chemical data. However, a large portion of pain measurement focuses on the aspects of pain which are beyond the physiological. 'Whatever the biological parameters of the symptoms, they alone may be insufficient to explain the patient's response" (Weinman, 1981, cited in French, 1987). In measuring pain, researchers look at the conscious reactions of subjects to pain, including sensory, affective, and evaluative aspects (Melzack, 1975).

When choosing any measurement tool, there are many factors which researchers must consider. Researchers must assess the reason for measurement and consider the population which will be studied. Also of importance is the ease with which a measurement tool can be administered and the properties of the measurement tool (MacDougall et al, 1991). Once a measurement has been selected, it is important to examine the reliability and validity of the tool. Two measurement scales have been employed extensively in pain research. The Visual Analogue Scale (VAS) is a convenient measure of the intensity of pain. Another scale prominently used is the McGill Pain Questionnaire (MPQ), designed as a multi-dimensional scale measuring sensory, affective, and cognitive aspects.

VISUAL ANALOGUE SCALE (VAS)

Description of VAS

The Visual Analogue Scale was one of the first scales to be developed in the measurement of pain (Huskinsson, 1974, Scott & Huskinsson, 1975). The VAS was designed to measure pain intensity. It reduces the pain experience to a single measurement along a continuous scale. The VAS is a ten to twenty centimeter line, horizontal or vertical, with word anchors. Word descriptors are placed along the line in some cases. The patient makes a mark between two extremes which indicates the intensity of the pain. This mark represents the intensity of pain which the patient is experiencing.

Properties of VAS

Scott and Huskinsson (1979) discussed the difference between the vertical and horizontal versions of the analogue scale. They found a very high correlation between the two scales ($r= 0.99$) and determined that while the vertical scale scores were slightly higher, the most important factor is that the type of scale remain consistent within a study.

The reliability of the Visual Analogue Scale has been examined. Work by Seymour et al (1985) has shown that scales between ten and fifteen centimeters are more reliable than those that are five or twenty centimeters long. Carlsson (1983) examined chronic pain patients and questioned the reliability of the VAS. Patients seemed varied in their ability to use the VAS, due in part to the difficulty in recalling a previous pain experience. Also, as pain decreased, the reliability of the scale was found to decrease (Carlsson, 1983). When working with comparative scales, where numbering was present, and absolute scales, Carlsson found the absolute scale to be more reliable. Results from Langley and Sheppeard's work (1983) with pain relief and pain severity found that the middle scores of the VAS were linearly related to the Verbal rating scale, but results at the extremes were not.

Langley and Sheppeard (1985) questioned the validity of the VAS for several reasons, including the physical structure of the scale and patient behavior toward the scale. Langley and Sheppeard (1983) cite the poor correlation between the MPQ, the Verbal Rating Scale, and the Visual Analogue scale as evidence of the validity problems with the Visual Analogue Scale. However, Price et al (1983) found the VAS to be internally consistent with responses to experimental pain, chronic pain, and direct temperature, demonstrating the validity of the VAS for measuring and comparing chronic pain and experimental heat pain. Utility with dancers is unknown.

Scott and Huskinsson (1979) consider the Visual Analogue Scale to be highly sensitive citing the high uniformity of responses as a main factor in its sensitivity. This uniformity means that there is a fairly even distribution of responses along the line. Further, Huskinsson (1983) cited a large capacity for the VAS to change in response to a stimulus, such as treatment. Carlsson (1983) agrees that the VAS is "highly sensitive", with a superior discriminating capacity.

However, the method of statistical analysis used with the Visual Analogue Scale has been debated. Carlsson (1983) stated that the VAS is not an interval scale and therefore does not lend itself to statistical analysis. This concept is disputed by other researchers. Price et al (1983), in their study of temperature pain, argued that the power functions in their study were predictive of estimated ratios of sensation or effect produced by pairs of standard temperature, thereby producing direct evidence for ratio scaling properties of the VAS. Further, the similarity of power functions derived from the VAS and direct line production methods confirm that VAS methods are variant of cross-modality matching and that no radical scaling biases are introduced by anchoring each continuum with verbal descriptors.

Adaptations of VAS

The Visual Analogue Scale has been adapted for a variety of uses. Langley and Sheppeard (1985) studied two versions of the VAS. The Visual Analogue Pain Relief Scale (VAPRS) indicated the level of pain which has subsided due to treatment. Advantages of the system include the fact that the magnitude of the response is not dependent on the initial pain severity. It is, however, not without problems. The VAPRS did not allow patients to record an increase in pain and may have given a false impression that all patients start with similar degrees of pain.

A second adaptation by Langley and Sheppeard (1985) was the Visual Analogue Pain Severity Scale (VAPSS). This involved marks made on two scales before and after treatment. Measurements were made between the mark and the lower end of the scale. This allowed the patients to record increases or decreases in their pain. Patients were also not dependent on the memories of their pain. Unfortunately, this estimation of pain introduces a double measurement error when comparing before and after scales. Langley and Sheppeard (1985) found that although both the VAPRS and the VAPSS had problems, the VAPSS was less prone to bias.

Work by Badley and Papegeorgiou (1989) examined the relationship between overall pain and pain at specific joints at rest and during movement in arthritis patients. Patients filled out a VAS with the extremes "no pain" and "pain as bad as it can be" both at rest and after movement of their affected limbs. They found that pain was more often recorded during movement then at rest. The assumption that overall pain was derived from the pain experienced in individual joints was found to be correct, but only during or after movement. The researchers concluded that overall pain as conventionally measured on the VAS may not reflect the total pain experience of the patient.

A comparative version of the VAS using degree of pain relief is also used in Carlsson's (1983) study. This involved a standard baseline for all subjects of unchanged pain, with increased and decreased pain used as endpoints . The results were inconclusive regarding pain relief However, although a consistent relationship was elusive, some type of relationship was indicated between the VAS and the comparative Pain Relief VAS. Carlsson (1983) cautioned that patients should complete each scale without being able to compare with previous estimates, when before and after treatment scales were used.

Berry and Huskinsson (1972) used a calibrated VAS to assess treatment in Rheumatoid Arthritis. Comparing an original scale and one with the word descriptors of none, mild, moderate, and severe, the researchers found that the calibrated version with word descriptors was a satisfactory method of assessing pain.

Advantages and Disadvantages of VAS

Despite the various debates, there are several advantages to using the Visual Analogue Scale. The VAS is widely considered to be one of the best methods for estimating pain intensity (Carlsson, 1983). Convenience is another advantage (Carlsson, 1983). The Visual Analogue Scale is considered a useful tool because of its sensitivity, simplicity, reproducibility, and universality (Scott & Huskinsson, 1979). Carlsson (1983) stated that the VAS is widely considered to be one of the best methods for estimating pain intensity. Although problems with the Visual Analogue Scale have been recognized, the major criticism is its inability to measure aspects other than pain intensity. Reliability is questioned if patients do not grasp the concept of the scale. Also, the respondents views of their pain may not reflect the objective phenomenon of pain (Scott & Huskinsson, 1979). Variations have been found in the length of lines after reproduction, leading to measurement error. Doubts have also been raised regarding the relationship between the measurement (VAS) and the pain experience. Scott and Huskinsson (1979) state that the VAS may not be an accurate reflection of the condition to be measured. Although there is mathematical support for the VAS, the major disadvantage is that the results have no descriptive value (Berry & Huskinsson, 1972). The VAS fails to adequately explain or describe the pain experienced by subjects.

While the Visual Analogue Scale is considered a "robust, sensitive, and reproducible method of expressing pain severity" (Langley & Sheppeard, 1985), Langley and

Sheppeard (1985) suggest researchers should examine the McGill Pain Questionnaire for a more accurate picture of pain as it measures more than pain intensity.

McGILL PAIN QUESTIONNAIRE (MPQ)

Description of MPQ

The McGill Pain Questionnaire was developed by Melzack (1975) and was "designed to provide a quantitative measure of clinical pain that can be treated statistically". It was hoped that the questionnaire would be "sufficiently sensitive to detect differences among different methods to relieve pain". Melzack's model plays an integral role in the questionnaire. According to Melzack, pain is composed of three aspects: sensory, affective, and cognitive components. The questionnaire was developed to reflect these aspects. Melzack and Wall recognize that the psychological and social aspects are central to the experience of pain and behavior associated with it (French, 1987).

Melzack and others worked with pain patients, doctors, teachers, and students to develop word descriptors for the MPQ. These make up the Pain Rating Index where the words are categorized into sensory, affective, evaluative, and miscellaneous classes. The words are divided into sixteen subclasses, where each of the words in the class appear synonymous but are varied in intensity.

Properties of MPQ

The McGill Pain Questionnaire's theoretical construct has been supported by many studies. Lowe et al (1991), attempted to confirm the underlying theories behind the MPQ, through a study of women with labor pain and post-operative pain. The researchers chose the Pain Rating Index (PRI) of the MPQ, because it provided quantification of sensory, affective, and evaluative components of pain and was also the most frequently used scale able to discriminate between two different pain groups. Lowe et al (1991) found that a multi-sample CFA supported invariance of the factor pattern, factor loadings, and factor correlations of the MPQ within two acute pain samples consistent with the theoretical model proposed by Melzack. Coefficient alpha reliability estimates for the two samples found the sensory subscales to be 0.68 (labor) and 0.70 (post-operative) and the affective subscales to be 0.71 and 0.81 respectively. The authors found support for the theoretical construct and reliability of the MPQ and acknowledged the classic contributions of the MPQ in the study of pain (Lowe et al, 1991).

Holroyd et al (1992) examined relationships between the PRI subscales and measures of psychological disturbances to support discriminant validity and clinical utility of the PRI, through a study of patients with lower back pain. The validity of the PRI as a multidimensional was examined. The chi-square difference test (X = 108.5, p0.001) showed the 3-factor model provided a better fit than a one dimensional model. Further, the test also showed that the 4-factor model was superior to the 3-factor model. When the subclasses are divided into four categories (sensory, affective, cognitive, and miscellaneous), problems with validity can be avoided, and the PRI can assist patients in describing their pain.

Adaptations of MPQ

The McGill Pain Questionnaire has been widely adapted to suit many different studies. The questionnaire can be used in its entire form, or the Pain Rating Index used on its own. The scale can also be used qualitatively, where subjects choose words which describe their pain (as many as they want) to develop a more complete description of their pain.

The McGill Pain Questionnaire has also been translated into many different languages. The work of Strand and Wisnes (1991) focused on the development of a Norwegian scale. They attempted to create a multidimensional measuring instrument for pain based on the MPQ. Work has also been completed on the French version of the MPQ. Boureau et al (1992) looked at the validity of four French versions. The researchers were concerned at the lack of exploration regarding the validity of the measurement tool. Pain descriptors were presented to forty-four physician judges to be assessed on four levels; validity, classification, subclassification and intensity. Through the study of these words, the researchers were able to construct a new version of the MPQ.

Advantages and Disadvantages of MPQ

The MPQ is a multi-dimensional model has been shown to be valid and reliable. Another advantage of the MPQ is its ability to provide a more complex picture of the pain than earlier measurement tools. It attempts to move beyond just the intensity of pain. The model upon which it is based allows for three different aspects of pain to be recognized and measured. Because of this, the researcher gains an in depth knowledge and greater understanding of the pain experienced. Data indicates that the MPQ is sufficiently sensitive to detect differences among different methods to relieve pain (Melzack, 1975).

The McGill Pain Questionnaire has been the subject of a variety of concerns. When administered, the MPQ subjects must understand that only one word is to be chosen in a subclass and that they are not obligated to choose a word in every class. Using more that one word in a class disrupts the scoring, but this variation has been used in some qualitative adaptations. It is also difficult for some subjects to accurately recall their pain. Between subjects, it is impossible to assess the actual pain that is being felt. What is "distressing" to one subject may be "excruciating" to another as the overall evaluation is determined not only by the sensory and affective dimensions of the pain, but also by the patients' past experience, mood and expectations. The MPQ's complex questionnaire has been associated with concerns regarding language and understanding. Subjects' literacy levels are important for result accuracy. Studies which employed the MPQ suggest that pain may be influenced by the frequency of pain as well as the severity (Hunter et al, 1979, Roche & Gijebers, 1986 cited in Roche, 1993). These concerns must be carefully addressed by researchers.

The McGill Pain Questionnaire has been shown to be a reliable and valid method for assessing pain. This multi-dimensional measurement tool has been successful in examining the sensory, affective, and cognitive aspects of pain as reported by patients. Melzack's model of pain has been shown to be an accurate theoretical construct for the scale, which has had statistical relevance.

METHODS

SUBJECTS

Twenty four subjects were obtained from three local ballet schools offering professional dance training. Participation was restricted to female dancers to alleviate physical concerns, such as the differences in the pelvis, Q angle, and bi-iliac width between males and females. The availability of female subjects, as compared to male dancers, was also a factor. Further, male dancers tend to have highly accelerated training, when compared to females (Covlin, 1993) and this may have an effect on the rate of injury. Dancers were screened for adherence to the following criteria: between the ages of fifteen and twenty years, dancing in the Royal Academy of Dance or Cecchetti Intermediate and Advanced Syllabus levels, and dancing ten or more hours a week. Training in one of the two main ballet technique methodologies at the top levels ensured that the dancers were participating in very similar classes and had a common level of expertise. Clanin (1993) suggested that determining an average range of flexibility correlated with degree of technical expertise would prove more helpful in identifying dancers with potential risk of injury. However, this determination of technical expertise would be highly subjective at best. A possible way to address Clanin's concerns would be to restrict the subject population to dance syllabi where the technical expertise is more standardized. This way, dancers in the Intermediate and Advanced levels have shown, through international dance expert examiners to possess the technical expertise to study beyond the Elementary level.

Three dance schools with professional training, of more than ten hours a week, were selected. These schools were chosen for their excellent training.

Subjects were tested on a day in which they had participated in at least one ballet class. They were also advised to be "warm" for the testing and were given twenty minutes to prepare. Ideally, all of the dancers would have taken the same class immediately prior to the testing. However, this was impossible as the dancers were from different locations and were tested several hours apart. Subject testing occurred on a Wednesday so that all dancers would have had the same number of consecutive days in class prior to the testing.

TESTING PROCEDURE

Subjects were evaluated one at a time in a private testing room. The subjects range of motion at the hip was assessed during external rotation, internal rotation, abduction, adduction, extension, and flexion. These measurements were chosen for their importance in previous studies. Hip flexion and extension has been widely studied in dancers (Jacobs & Young, 1978, Clippenger-Robertson, 1990, Knapik et al, 1992, Reid, 1987, Moscov et al, 1994, Miller et al, 1993, and Legreci-Mangini, 1994). Abduction measurements were found to be important by Jacobs & Young, (1978) Reid, (1987) and Legreci-Mangini (1994), especially when combined with external rotation (Kushner, 1990, Legreci-Mangini, 1994). Internal rotation, external rotation, and adduction have been cited as important factors in predicting snapping hip and hip pain (Knapik, 1992, Jacobs & Young, 1978, Reid, 1987, Clippenger Robertson, 1990, and Legreci-Mangini, 1994). Range of motion was measured both actively and passively as described below. Clanin (1993) recognized the importance of active range of motion for dancers. However, she encouraged researchers to measure both active and passive range of motion in both the neutral and externally rotated positions as all of these are used in choreography. Passive range of motion is frequently seen in partnering and floor work. Clanin (1993) stresses the importance of examining both ranges and their relationship to each other. These ranges were measured in degrees with the use of the Leighton Flexometer. Protocols for this type of measurement were taken from the Physiological Testing of the High Performance Athlete (1991) and adapted as described below. The Leighton flexometer was chosen over a goniometer due to problems with the latter associated with reliability in the difficulty of identifying the axis of motion as well as positioning and maintaining the arms of the goniometer along the bones (Hubley-Kozey, 1991). Researchers have chosen the Leighton flexometer for its high reliability and ease of use (Kushner et al, 1990). Test-retest reliability has been shown to be 0.83 or greater (Hsieh et al, 1983). A pilot study showed the intratester reliability with the flexometer to be 0.87 for this study.

External and internal rotation were measured while the subject was lying supine on an examination table (Jacobs & Young, 1978). The flexometer was strapped to the sole of the foot as described in Hubley-Kozey(1991). Passive and active external and internal rotation were measured with the foot dorsiflexed which simulated the dancer standing on the floor.

For external rotation, the researcher focused on maintaining the alignment on the central thigh, midpoint of the patella and the midline of the ankle joint to avoid rotation at the knee and ankle (Clippenger-Robertson, 1990). The knee remained completely extended (Jacobs & Young, 1978). Rotation was allowed on the testing side only. It was important that the non testing side remained neutral. Flattening or hyperextending of the lumbar spine was carefully monitored. The anterior superior iliac spines were checked and had to remain level to avoid twisting of the pelvis toward the testing leg. When internal rotation was measured, the nontested leg was carefully monitored to avoid twisting or shifting in the pelvis or spine similarly to the measurement of external rotation.

Abduction, adduction, flexion, and extension were measured with the subject standing beside a ballet barre. Standing measurement was practical as it provided the most accurate representation of the dancer at work. The flexometer was strapped to the thigh just proximal to the knee. This adaptation was required due to the extreme range of motion of the dancers. Conventionally, the flexometer is higher, but when the dancer abducts or flexes, the flexometer is pressed into the dancer's upper body, making reading the flexometer or adjusting dial difficult.

Hip Flexion was measured with both the supporting and tested knee remaining extended as used by LeGreci-Mangini (1994) and Miller et al (1993). Movement of the pelvis and the lumbar spine was monitored to avoid recording including this motion in hip ROM. (Clippenger-Roberston, 1990). The level of the anterior superior iliac spines also needed to remain equal. The foot of the tested leg was plantar flexed, to as closely as possible simulate dancing situation (Miller et al, 1993).

When hip flexion was measured with external rotation, protocols were followed as above, but the researcher checked carefully to ensure that turnout used was established at the hip joint and maintained along the length of the lower limb (Clippenger-Robertson, 1990).

Hip extension was measured in the neutral (parallel) position. The aim of the researcher was to measure only the extension abilities at the hip, not of the lumbar spine and pelvis. It was therefore made sure that the hips remained square, the anterior superior iliac spines remained both level and parallel to the floor. Knees were extended during the testing and were checked to ensure that they remained this way. It was also noted that the dancers could not "sink" into the supporting hip, that there was no relaxing of the supporting side forward to gain more extension (Moscov et al, 1994).

Abduction was measured with the foot plantar flexed as in most ballet movements (Miller et al, 1993). Measurement in both neutral and with external rotation was taken with the supporting leg in the same position. The knees remained extended throughout the measurement (Miller et al, 1993). Care was taken to ensure that the anterior superior iliac spines remained level and equal .

Following the measurements described above, a questionnaire was administered to subjects. Demographic information was also gathered in regards to age and dance training.

The dancers estimate of their own flexibility on a visual analogue scale with word anchors of "not at all flexible" and "extremely flexible". The questionnaire also sought responses regarding hip discomfort through utilization of both the VAS and MPQ scales. "Discomfort" was used instead of the term "pain".

When measuring pain, it has been widely recognized that pain intensity, as measured by the VAS, while an important measure, does not provide a complete picture of the pain experience (Bradley & Papegeorgio, 1989, Scott & Huskinsson, 1979, and Berry & Huskinsson, 1972). Alternatively, the McGill Pain Questionnaire provides a more in-depth look at pain experiences but is not as easily and accurately quantifiable (Hunter et al, 1979, Roche, 1993). Therefore a combination of the scales provided the researcher with a comprehensive measure of pain experience. Using the VAS, of the ten centimeter size, provided a simple measure widely accepted to indicate intensity, while the MPQ provided in-depth insight into the pain.

Sections of the McGill Pain Questionnaire were administered as related to the frequency, degree, and location of hip discomfort. A Visual Analogue Scale was filled out immediately after ballet movements were performed: Grand battement devant (flexion with external rotation), grand battement seconde (abduction with external rotation), and grand ronde de jambe, which combines movement from flexion to abduction and back, all with external rotation.

The Pain Rating Scale of the McGill Pain Questionnaire was administered to assess the hip discomfort felt by the subject. Upon completion of the scale, subjects were asked to list any descriptors which would help to describe the sensation. Questions from the MPQ regarding the actions or events which increased or decreased discomfort were included, as well as descriptors of the discomfort at its worst and least.

STATISTICAL ANALYSIS

The subjects flexibility data was analyzed to determine which dancers were highly flexible or highly inflexible. Work by Cowan et al (1988) divided subjects into quintiles where the lowest quintile was termed inflexible and the highest extremely flexible. Since the amount of data available in dance research was not conducive to forming quintiles, means and standard deviations from the present passive measures were used. For each movement the middle sixty eight percent was determined (Knapik et al, 1992), giving a range of "normal" passive flexibility for flexion, extension, abduction, abduction with external rotation, adduction, internal rotation and external rotation. By taking the mean score of each dancer, the data formed three distinct groups of subjects, Group 1 inflexible (lower 16%), Group 2 moderately flexible (middle 68%), and Group 3 extremely flexible (highest 16%). For analyzing purposes, Group 4 consisted of all subjects in Groups 2 and 3 in order to examine the limits of flexibility as suggested by Knapik et al (1990).

Correlation Tables: The flexibility variables and the pain descriptors of the McGill Pain Questionnaire were correlated. (see Appendix B) Correlation coefficients measured the strength of the linear relationship between two variables. "Two variables are related if knowing the value of one variable tells us something about the value of the other variable" (Norusis, 1990). This information detailed whether the relationship between flexibility and pain was positive or negative and gave information on the strength of this relationship (Baumgartner & Strong, 1994). Correlations determined possible relationships between flexibility measures and pain measures.

T-Tests: T-tests were performed to detect difference between the four groups: moderately flexible, most flexible, least flexible, and limits of flexibility (Group 4). It established the significance of the differences between the means of each group. Whether the flexibility groups have significantly different ($p \leq 0.05$) levels of pain were determined through t-tests and correlations.

In any study dealing with correlations, the researcher must make a personal decision about which level of correlation is acceptable. In this case, where the study is exploring possible relationships, rather than confirming already well established ones, it was important not to discount relationships that may be important. For this reason the researcher chose to accept a correlation of 0.3000 and above or -0.3000 and below. This decision rules out a type 2 statistical error, where the researcher assumes there is no relationship between two variables when in fact there is a relationship. This type of error is less acceptable for the purpose of this study than a type 1 error - where the researcher assumes a relationship but there is none. This type 1 error is far more acceptable to this study than a type 2 error. Further research is needed to examine the strength and important of the correlations found. When t-tests were performed, a similar decision had to be reached. In this study, a level of $p < 0.05$ was considered important, to avoid the type 2 statistical error, however the more sensitive result of $p < 0.01$ significance was reported as such.

Passive and Active Range of Motion

As described above, the dancers were each assigned a passive flexibility score, determined by the average of their relationship to the flexibility mean. Using the same methods, each dancer was also assigned an active flexibility score using the active measures. In addition, a total pain score was calculated. This was the summation of the pain measures in the study. Also calculated was the partial pain score, where the pain score were added, but without the VAS for individual ballet movement discomfort at present. This was done to give a score of past pain experiences, without influence of their pain experiences on the day of testing.

LIMITATIONS

1. Students did not/could not participate in the exact same class immediately prior to testing.

2. Students could not all be tested immediately after finishing class. Therefore, some students were "colder" than others.

3. No pain tolerance or pain coping measure was taken. Pain measurements are subjective (as all are), and are based on the experiences and tolerance of each individual subject.

4. Pain measurements may indicate some type of injury, however these types of pain measurement do not grade the severity of the injury in any way, nor can they diagnose the type of injury.

5. Reliability of the researcher reading the flexometer, reported from a pilot study to be 0.87.

6. The "Martyr Syndrome", as discussed in the Literature Review, may have influenced the true reporting of pain experiences, in both over and under reporting discomfort.

RESULTS

This study examined the relationships between the balletic ranges of motion, the non balletic ranges of motion, and hip discomfort. The results in this study will be reported according to Personal Data, including bi-iliac width, Balletic Flexibility, Non balletic Flexibility and Hip Discomfort measures. Balletic flexibility includes the ranges of external rotation, flexion, flexion with external rotation, abduction, abduction with external rotation and extension. The Non balletic ranges include adduction and internal rotation.

The mean age of subjects was 16 years (range 15-20 years), and they had an average of 11 years (range 6-16 years) of training. It was established that the mean of dancers' years of serious study was 6 (range 4-10 years). Ten dancers were training in the R.A.D. method, and fourteen in the Cecchetti syllabus. When asked to identify their own perception of their flexibility on a VAS, the average stated by dancers was 53 percent (range 30-86), with a standard deviation of 16. The dancers ranged in bi-iliac width from 17.5 cm to 24cm, with a mean bi-iliac width of 21 cm.

FLEXIBILITY MEASUREMENTS

External Rotation

The subjects means for passive external rotation on the right and left sides were 56 and 60 degrees respectively. Active external rotation averages were found to be 53 (right) and 54 (left) degrees.

TABLE 3 - EXTERNAL ROTATION MEANS AND RANGES

	PASSIVE		ACTIVE	
EXTERNAL ROTATION	Mean (deg)	Range (deg)	Mean (deg)	Range (deg)
Right	56	36-75	53	32-75
Left	60	40-90	54	35-80

Abduction

The dancers had a mean passive abduction value of 48 degrees on the right side, while the left was 49 degrees. Active abduction was found to be 42 (right) and 46 (left) degrees. When external rotation was added to abduction, the dancers achieved an average of 164 (right) and 159(left) degrees passively and 115 (right) and 111 (left) degrees actively.

TABLE 4 - ABDUCTION AND ABDUCTION WITH EXTERNAL ROTATION MEANS AND RANGES

ABDUCTION	PASSIVE		ACTIVE	
	Mean	Range	Mean	Range
Right	48 deg	32-70	43 deg	29-56
Left	49 deg	40-60	46 deg	32-68
ABDUCTION w EXT ROT				
Right	164 deg	130-178	159 deg	130-180
Left	115 deg	40-162	11 deg	42-165

Flexion

Passive flexion means were found to be 139 (right) and 136 degrees (left). The subjects were able to flex at the hip an average of 102 degrees on the right side and 95 degrees on the left. Flexion with external rotation on the right side reported a passive measurement of 139 degrees and an active measurement of 104 degrees. These values were 140 (passive) and 99 (active) on the left side.

TABLE 5 - FLEXION AND FLEXION WITH EXTERNAL ROTATION MEANS AND RANGES

	PASSIVE		ACTIVE	
FLEXION	Mean (deg)	Range (deg)	Mean (deg)	Range (deg)
Right	139	130-172	102	84-125
Left	136	94-170	95	72-127
FLEXION W EXT ROT				
Right	139	119-180	140	113-173
Left	104	72-139	99	80-124

Extension

Subjects were found to have an average passive extension flexibility on the right side of 26 degrees. The left passive extension mean was reported at 29 degrees. Active extension means were found to be 24 degrees (right) and 26 degrees (left).

TABLE 6 - EXTENSION MEANS AND RANGES

EXTENSION	PASSIVE		ACTIVE	
	Mean (deg)	Range (deg)	Mean (deg)	Range (deg)
Right	26	15-36	24	15-32
Left	29	17-35	26	17-35

Adduction

Adduction values for the right passive and active measurements were 17 and 12 degrees respectively. On the left, these means were 17 and 12 degrees.

TABLE 7 - ADDUCTION MEANS AND RANGES

ADDUCTION	PASSIVE		ACTIVE	
	Mean (deg)	Range (deg)	Mean (deg)	Range (deg)
Right	17	8-33	12	5-20
Left	17	6-30	12	2-21

Internal Rotation

The internal rotation means for the right side were 31 (passive) and 24 (active) degrees, while on the left side were measured at 29 (passive) and 24 (active) degrees.

TABLE 8 - INTERNAL ROTATION MEANS AND RANGES

	PASSIVE		ACTIVE	
INTERNAL ROTATION	Mean (deg)	Range (deg)	Mean (deg)	Range (deg)
Right	31	14-50	24	8-40
Left	29	12-45	24	10-45

DISCOMFORT MEASURES

For the estimated discomfort that the dancers have experienced, an average of 1.54 out of 3 (0 - no discomfort, 3 constant discomfort) was reported. Three (13%) of the subjects related that they had never experienced hip pain. There were ten dancers (42%) who suffered hip discomfort occasionally, while six subjects (25%) frequently experienced discomfort. Five (21%) of the dancers constantly experienced hip discomfort. The average degree of this discomfort had a mean of 41.78 percent on a VAS (range 0-95). The degree to which the discomfort affected dancing was reported to be 1.33 (0 - not at all, 3 - extremely).

The mean of PRI scores reported by the subjects was 13.92 with a standard deviation of 14.39 (range 0-49). This figure represented the sum score of words selected, with a total possible score of seventy eight. Nine (38%) of the subjects added the words “clicking”, “snapping”, or “cracking” to the word descriptors of the PRI. Pain at the present time reported a mean of 0.75, where zero was no pain and one was mild pain. Fifteen of the subjects (63%) reported no pain at the present time, while three (13%) were experiencing “mild” discomfort. Four dancers (17%) described their experiences as “discomforting” at present, and one (4%) “distressing”. Pain at its least a dancer had experienced had a mean of 0.71 out of four, where zero was no pain and one was mild pain, with twelve dancers (50%) reporting no pain. At its least, seven dancers (29%) described their pain as “mild”, while four (17%) said it was “discomforting”. One dancer (4%) described her pain at its least as “distressing”. Pain at its worst was reported at a mean score of two out of five, where two was “mild” pain and five was “excruciating”. Three dancers (13%) said they had no hip pain, while two (8%) reported their pain at its worst as being “mild”. Six dancers (25%) chose the word “discomforting” to describe their worst pain, and seven (29%) used distressing. “Horrible” was the pain at its worst for four dancers (17%). Two subjects (8%) found their pain at its worst to be “excruciating”.

Coding for Passive Range of Motion (PROM) and Active Range of Motion (AROM) Scores

In order to divide the subjects into flexibility groups, subjects were coded for each movement according to their relationship to the flexibility mean. Subjects were coded as “zero” if they were more than one standard deviation below the mean. They were coded as “one” if they were within one standard deviation on either side of the mean, and as “two” if they were greater than one standard deviation above. This process was repeated and subjects were coded for each of the flexibility measurements. Internal rotation and adduction were coded in reverse as suggested by Reid (1990). The codes for the passive measurements of each of the subjects were averaged to obtain an overall flexibility score. The subjects were grouped as inflexible (below 0.87), moderately flexible (0.87-1.13), and highly flexible (above 1.13). Six subjects were placed in the inflexible group and five into the highly flexible group, thus leaving thirteen dancers in the moderately flexible group. The coding process was repeated for the active flexibility measurements (AROM), and each subject was assigned an overall AROM score. The subjects were not grouped according to these AROM scores, so that co-ordination, muscle strength or other aspects involved in active flexibility did not affect the flexibility groupings. The average strength scores were 0.89 for the least flexible group, 1.0 for the moderately flexible group, and 1.11 for the most flexible group.

CORRELATIONS

Correlation tables were calculated between all of the variables. Correlations of 0.3000 and above or -0.3000 and below were considered in this study reducing the possibility of a type 1 statistical error (see statistical analysis section in Methods).

PERSONAL DATA

Age was found to have a positive correlation with two factors, years of training (0.3805) and age (0.4288). A negative correlation was observed between age and passive adduction of the left side (-0.3114). Left passive abduction with external rotation had a negative correlation of -0.3770 with age. Correlations at the negative 0.4 level were found between age and left passive abduction (-0.4016) and left active abduction (-0.4148).

The years a dancer had been training correlated with fifteen other variables, six positively and nine negatively. Most of these correlations were at the 0.3 level. Internal rotation of the left side correlated with the years of training, both passively (0.3315) and actively (0.3036). The Pain score calculated as the sum of the VAS was found to have a correlation with the years of training of 0.3138. The bi-iliac width of the dancers related to their years of training at the level of 0.3605. The PRI had a positive correlation (0.3632) with the years of training. The number of years of dancing was also correlated with the number of serious years of training (0.5577). Passive abduction with external rotation on the right side was negatively correlated the years of training, at the -0.3142 level. Also found was a relationship with passive left (-0.3916) and active right (-0.4009) abduction with external rotation. Years of training was also found to correlate with left active abduction (-0.3145), as well as on the right side (-0.3263). At the level of -0.3311, years of training related to active extension on the right side. Years of training had a negative correlation with both passive (-0.3311) and active (-0.3319) flexion with external rotation. The highest negative correlation involving years of training was with passive adduction on the right side.

TABLE 9 - CORRELATIONS BETWEEN YEARS OF TRAINING AND ABDUCTION WITH AND WITHOUT EXTERNAL ROTATION

Correlation with Years of Training	Level
Right Passive Abduction with External Rotation	-0.3142
Left Passive Abduction with External Rotation	-0.3916
Right Active Abduction with External Rotation	-0.4009
Left Active Abduction	-0.3145
Right Active Abduction	-0.3263

Serious years of training was found to have positive correlations with six variables. The number of years of serious training related to the bi-iliac width of the dancers at the 0.3183 level. The PRI index was correlated with serious training at 0.3606. Internal rotation correlated to serious years of training, both in passive (0.4162) and active (0.3660) ranges. Hip discomfort at its least (0.4719) was also correlated with serious years of training. A negative correlation was reported between serious years of training and active abduction of the left side. Correlations were found between three of the abduction with external rotation measurement and serious years of training, passive left (-0.3277), active left (-0.3397) and active right (-0.4932).

TABLE 10 - SERIOUS YEARS OF TRAINING CORRECTIONS WITH EXTERNAL ROTATION

Correlation with Serious Years of Training	Level
Right Active Abduction with External Rotation	-0.4932
Left Passive Abduction with External Rotation	-0.3277
Left Active Abduction with External Rotation	-0.4932

FLEXIBILITY ESTIMATE

The subjects estimate of their own flexibility had only positive correlations. It was found to be related to seven variables, ranging from 0.3231 to 0.5801. Active internal rotation on the left side was correlated with training at the 0.3231 level. A correlation of 0.3414 was found between passive right flexion and training. Flexibility was related to the type of training (0.4501). The dancers estimate of their flexibility correlated with all four external rotation variables, passive right (0.3674), active left (0.4021), active right (0.4749), and passive left (0.5801).

TABLE 11 - FLEXIBILITY ESTIMATE CORRELATIONS

Correlations with Flexibility Estimate	Level
Right Passive External Rotation	0.3674
Left Passive External Rotation	0.5801
Right Active External Rotation	0.4749
Left Active External Rotation	0.4021

BI-ILIAC WIDTH

Bi-iliac width measurements were found to correlate with ten variables, three positively and seven negatively. Both the years of training (0.3605) and serious years of training (0.3183) were important. The degree to which the dancers hip discomfort affected their dancing correlated with bi-iliac width at the 0.4120 level. Bi-iliac width was found to have a negative correlation with passive flexion with external rotation on the left side (-0.3138) and on the right (-0.4153). Similarly, both passive right and left abduction with external rotation were related to bi-iliac width (-0.3250, -0.5176). Bi-iliac width was also reported to correlate with passive flexion (left -0.3155 and right -0.5355).

TABLE 12 - BI-ILIAC WIDTH CORRELATIONS

Correlations with Bi-iliac Width	Level
Right Passive Flexion with External Rotation	-0.4153
Left Passive Flexion with External Rotation	-0.3138
Right Passive Abduction with External Rotation	-0.3250
Left Passive Abduction with External Rotation	-0.5176
Right Passive Flexion	-0.5355
Left Passive Flexion	-0.3155

FLEXIBILITY MEASURES

EXTERNAL ROTATION

Right passive external rotation was be reported to positively correlated with three of the flexion with external rotation variables, active left (0.3189), passive left (0.4139), and passive right (0.4785). The subjects estimate of their own flexibility was correlated with passive external rotation on the right side at the 0.3674 level. Further, the other three external rotation variables were related to passive external rotation on the right. These were passive left (0.7945), active right (0.8297) and active left (0.8851).

Right active external rotation was found to correlate with nine variables. Along with the other external rotation variables, estimated discomfort, abduction with external rotation, flexion, flexion with external rotation, and estimate of flexibility were positively correlated. Pain during grande battement devant and ronde de jambe from front to side, both on the left side, were negatively correlated. Estimated discomfort was correlated at the 0.3552 level with active external rotation on the right side, as was subjects estimate of their flexibility, at 0.4749. Abduction with external rotation, passively on the right side was found to relate to right active external rotation (0.3807). Right passive flexion was correlated with right active external rotation at the 0.5523 level. Active right external rotation was related to the three other external rotation variables, left passive (0.7120), left active (0.7192), and right passive (0.8279).

Passive external rotation on the left side correlated with passive flexion with external rotation on the left side (0.3370). Passive flexion on the right, without external rotation, was also related, at the 0.5018 level. The subjects own estimate of their flexibility was correlated at the 0.5801 level to left passive external rotation. External rotation active right, passive right, and active left were all correlated with left passive external rotation at the 0.7120, 0.7945, and 0.8652 levels respectively. Left passive external rotation was negatively related to two abduction variables passive right abduction (-0.3544) and active right abduction (-0.3654). The degree the discomfort affected dancing was also correlated (-0.4501).

Active external rotation was related to passive abduction with external rotation on the right side at the 0.3198 level. Passive and active flexion on the right side were seen to correlate with active left external rotation, at 0.3863 and 0.5527 respectively. Active left external rotation correlated with both passive flexion with external rotation on the right (0.4676) and the dancers estimate of their flexibility (0.4021). Active external rotation on the left was related to the other external rotation measurements, as seen before, at the 0.7192 (right active), 0.8652 (passive left), and 0.8851 (passive right) levels. Negative correlations with active left external rotation were passive and active right abduction (-0.3915 and -0.3002). Also negatively related was pain during grande battement devant with the left leg (-0.3096). Related to -0.4502 was active left external rotation. The degree to which discomfort affected dancing was at the -0.5383 level.

ABDUCTION

Passive abduction on the right side was found to relate to three variables. Active right abduction was correlated at the 0.7254 level. Passive and active external rotation were both negatively correlated with right passive abduction, at the -0.3654 and -0.3915 levels. Active right abduction was also related to three variables, passive right abduction (0.7254), and passive (-0.3002) and active (-0.3544) external rotation.

Left passive abduction was correlated with only one variable positively. This was left active abduction, at 0.7727. Negatively correlated to left passive abduction were left passive (-0.3049) and active (-0.3220) internal rotation. Also negatively related were the Pain Rating Index, at the -0.3163 level, and hip discomfort at present, at -0.3163. The subjects age was related at -0.4016 to left passive abduction.

Left active abduction was found to relate to thirteen variables above 0.3000 or below -0.3000, eight positively and five negatively. At the 0.3836 level, active flexion with external rotation on the right was correlated to left active abduction. Left active abduction was related to both right and left active flexion with external rotation, at 0.3995 and 0.4715 respectively. Abduction variables for active left were also related to left active adduction (0.4311). Right active flexion was related at .4510. Left active abduction was related to passive left (0.7727) and active right (0.3177) abduction. A negative correlation was found between the years of dance training and left active adduction (-0.3145). Similarly, there was a relationship between serious years of training and left active abduction (-0.3621). Left passive internal rotation was found to relate at the -0.3161 level. Left active abduction was related to the worst hip discomfort (-0.3186) and to age (-0.4148).

ABDUCTION WITH EXTERNAL ROTATION

Right passive abduction with external rotation was found to relate to many of the other flexibility, personal, and discomfort values. Related at the 0.3045 level was pain during Grande battement side on the right side, as well as the least hip discomfort felt (0.3367). Passive abduction with external rotation was found to relate to two external rotation variables, right and left active (0.3198 and 0.3807) and to right passive (0.3239). Also correlated were right passive and right active flexion, at 0.3626 and 0.3917 respectively. Right active extension was related to passive right abduction with external rotation at the 0.4118 level. Both active (0.4094) and passive (0.5062) flexion with external rotation on the right side were correlated with right passive abduction with external rotation. The three other abduction with external rotation variables were correlated with passive right abduction with external rotation. These were active left (0.3073), passive left (0.3412) and active right (0.3794). Right passive abduction with external rotation was negatively correlated with the number of years of dance training (-0.3142). Also negatively related was the bi-iliac width of the dancers (-0.3250). Correlated at the -0.4328 level was right passive abduction.

Right active abduction with external rotation was found to correlate with right active adduction at the 0.3316 level. Also related to active abduction with external rotation on the right was left passive flexion (0.3617), left active flexion (0.5221), and right active flexion (0.7406).Abduction with external rotation actively on the left side was related at 0.3995. Right active extension was related to right active abduction with external rotation to the 0.6128 level. Active abduction with external rotation on the right side was correlated with all four flexion with external rotation measures. These were passive right (0.3469), passive left (0.3838), active left (0.5198) and active right (0.6810). Right active abduction with external rotation was related to the three other abduction with external rotation variables, at the 0.3794 (passive right), 0.4215 (passive left), and 0.7612 (active left) levels. Active abduction with external rotation on the right side was shown to have a negatively relationship with hip discomfort at its worst (-0.3438) and also with the type of training (-0.3749). The number of years of training (-0.4009) and number of serious years of training (-0.4932) were also negatively correlated.

Left passive abduction with external rotation was found to relate to fourteen other measures. It was correlated with left active extension (0.3063) and right passive external rotation (0.3247). Also related to left passive abduction with external rotation was left passive abduction (0.3227). Two flexion with external rotation variables were correlated with left passive abduction with external rotation. These were passive right flexion at 0.3247 and passive left flexion at 0.4475. Passive flexion on the right (0.3388) and left (0.4238) sides were also correlated. Adduction, passively on the right side, was found to relate to left passive abduction on the right side to the 0.4623 level. Passive right and active left abduction with external rotation were related at 0.3412 and 0.6109, respectively. The number of year of training (-0.3916) and serious years of training (-0.3397) were negatively correlated with left passive abduction with external rotation. The age of the subject was also negatively related at -0.3770.

Left active abduction with external rotation was correlated with least hip discomfort felt (0.3000). It was also related to right active adduction at the 0.3007 level. Pain felt during ronde de jambe from side to back on the right was also correlated with left active abduction with external rotation (0.3041). Right passive adduction was correlated (0.3414), as was pain during ronde de jambe from side to front on the right side (0.3588). Right and left active extension were correlated with active abduction with external rotation on the right, at 0.3659 and 0.4559, respectively. Abduction, actively on the left side, was related to the same movement with turnout (0.4715). Right active flexion with external rotation was related to left active abduction with external rotation (0.5298) as was active left (0.6350). Two flexion variables were related to left active abduction with external rotation, active left (0.5357) and active right (0.5839). Left active abduction with external rotation was related to the three other abduction with external rotation measures, passive right (0.3073), passive left (0.6109) and active right (0.7612). There were three variables which negatively correlated with active abduction with external rotation on the left side. Serious years of training (-0.3277) and type of training (-0.3419) were both correlated with left active abduction.

TABLE 13 - CORRELATIONS BETWEEN ABDUCTION WITH EXTERNAL ROTATION AND FLEXION WITH EXTERNAL ROTATION

Abduction with External Rotation	Flexion with External Rotation	Level
Right Passive	Right Active	0.4094
Right Passive	Right Passive	0.5062
Right Active	Right Passive	0.3469
Right Active	Left Passive	0.3838
Right Active	Left Active	0.5198
Right Active	Right Active	0.6810
Left Passive	Right Passive	0.3247
Left Passive	Left Passive	0.4475
Left Active	Right Active	0.5298
Left Active	Left Active	0.6350

TABLE 14 - ABDUCTION WITH EXTERNAL ROTATION CORRELATIONS WITH FLEXION VARIABLES

Abduction with External Rotation	Flexion	Level
Right Passive	Right Passive	0.3626
Right Passive	Right Active	0.3917
Right Active	Left Passive	0.3617
Right Active	Left Active	0.5221
Right Active	Right Active	0.7406
Left Passive	Right Passive	0.3388
Left Passive	Right Passive	0.4138
Left Active	Left Active	0.5357
Left Active	Right Active	0.5839

FLEXION

Right passive flexion was related to the dancer's own estimate of her flexibility at the 0.3414 level. Also related to passive flexion on the right were the four external rotation variables, passive right (0.5429), active right (0.5523), passive left (0.5018) and active left (0.5527). Further, right passive flexion was positively related to both passive right and passive left abduction with external rotation (0.3626 and 0.3388). The three other flexion variables were correlated at 0.5269 (active right), 0.7787 (passive left), and 0.3604 (active left). Right passive flexion was related to passive flexion with external rotation on the right (0.7473) and left (0.6088). Negatively related was bi-iliac width (-0.5355).

Active flexion on the right was found to have a positive relationship to fifteen other variables. Passive external rotation on the right was correlated at the 0.3091 level, while left active external rotation was 0.3863). Active right flexion was related to active right extension (0.3665). Left active abduction was related to right active flexion at the 0.4510 level. Right passive (0.3917) and active (0.7406) abduction with external rotation were positively correlated with right active flexion as was left active abduction with external rotation (0.5839). Right and left passive flexion were related to right active flexion at 0.5369 and 0.6332, respectively. Left active flexion was also related (0.6332). Right active flexion was related to all four flexion with external rotation variables, passive right (0.4785), active right (0.7879), passive left (0.3618) and active left (0.5689).

Left passive flexion was found to correlated with both right active abduction with external rotation (0.3617) and left passive abduction with external rotation (0.4138). It was also related to the three other flexion variables at the 0.7787 (passive right), 0.4604 (active right), and 0.4728 (active left) levels. When external rotation was added to flexion, passive right (0.6204), passive left (0.7783) and active left (0.3395) were correlated with left passive flexion. Bi-iliac width was negatively related to left passive flexion, at -0.3155.

Left active flexion was related to fourteen variables, twelve positively and two negatively. Both right and left active extension were correlated with left active flexion, at the 0.5173 and 0.3235 levels respectively. Right passive adduction was also related (0.3440). Active flexion on the left side was correlated at the 0.5221 level with active right abduction with external rotation and 0.5357 on active left. Left active flexion was found to relate to the other flexion variables as well as all four flexion with external rotation variables. These correlations were 0.3604 (passive right flexion), 0.6332 (active right flexion) and 0.4728 (passive left flexion). Also related were right passive flexion with external rotation (0.4105), right active flexion with external rotation (0.6080), left passive flexion with external rotation (0.4139) and left active flexion with external rotation (0.8089).

FLEXION WITH EXTERNAL ROTATION

Right passive flexion with external rotation was found to relate to right (0.4491) and left passive external rotation (0.3770). Also related was left active external rotation (0.4676).

Right passive flexion with external rotation was correlated with left active adduction at the 0.3059 level. Three abduction with external rotation variables were correlated with right passive flexion with external rotation. These were right passive (0.5062), right active (0.3469) and left passive (0.3247). All four flexion variables were related to right passive flexion with external rotation, right passive (0.7473), right active (0.4785), left passive (0.6204) and left active (0.4105). Related at the 0.4754 and 0.6658 levels were right active and left passive flexion with external rotation. The number of years a dancer had been training was negatively related (-0.3311) to right passive flexion with external rotation. Bi-iliac width was correlated at -0.4153.

Right active flexion with external rotation was correlated with right active extension (0.4803) and with pain felt during ronde de jambe from side to front on the right side (0.3375). Right and left adduction were related to Right active flexion with external rotation at the 0.4127 and 0.3836 levels, respectively. Right active flexion with external rotation was correlated with three of the abduction with external rotation variables, passive right, passive left, and active left, at the 0.4094, 0.6810, and 0.5298 levels. Both right (0.7879) and left (0.6080) active flexion were related to right active flexion with external rotation. Passive right (0.4754), passive left (0.3535) and active left (0.6224) flexion with external rotation correlated with right active flexion with external rotation. Years of training was negatively correlated (-0.3319).

Left passive flexion with external rotation was found to correlate with right active extension (0.3381). Also related were right active (0.3838) and left passive (0.4475) abduction with external rotation. Left passive flexion with external rotation was correlated with right passive adduction at the 0.3063 level. Three flexion values were related to left passive flexion with external rotation, passive right at 0.3618, passive left at 0.7783, and active left at 0.4139. Left passive flexion with external rotation was correlated with the other three flexion with external rotation. These were passive right (0.6658), active right (0.3535) and active left (0.4304). Left passive flexion with external rotation was negatively related to bi-iliac width at the -0.3138. It was also related to right passive internal rotation (-0.3590), left passive internal rotation (-0.4639) and left active internal rotation (-0.3999).

Left active flexion with external rotation was related to both right (0.4116) and left (0.3911) active extension. Also correlated were right active and left passive abduction with external rotation, at 0.5[illegible]98 and 0.6350 respectively. Pain at its least was related at the 0.3802 level. Three flexion values were correlated with left active flexion with external rotation. These were right active (0.5689), left passive (0.3395), and left active (0.8089). Left active flexion with external rotation was also related to passive right (0.3189), active right (0.6224), and passive left (0.4304) flexion with external rotation.

EXTENSION

Passive extension on the right side was correlated with seven variables, all of them positively. Related to right passive extension was both right active and left passive extension (0.3196 and 0.4840). Pain felt during ronde de jambe from front to side on the left (0.3470) and from side to back on the right (0.3496) were both related to right passive extension. Three adduction variables were found to correlate, active right and left adduction and passive left adduction, 0.5089, 0.5198, and 0.7282 respectively.

Active extension on the right side was related to twelve other measurements, eleven positively and one negatively. Active internal rotation on the right side was correlated with active right extension to the 0.3015 level. Right passive adduction was related at 0.3026. Two other extension variables were correlated with active right, these were passive right (0.3196) and active left (0.4801). Active flexion on the right and left sides were related to active right extension, at the 0.3665 and 0.5173 levels respectively. Active flexion with external rotation was also correlated with active right extension, on the left (0.4116) and on the right (0.4803). Three of the abduction with external rotation variables were found to relate to right active extension. These were active left (0.3659), passive right (0.4118), and active right (0.6124).

When examining the correlations between passive left extension, a relationship was found between three adduction variables, active right (0.3032), passive left (0.3677) and passive right (0.4840). Internal rotation, passively on the left side was found to correlate at the 0.3290 level. Passive right extension (0.4840) and active left extension (0.5395) were also related to passive left extension.

Active left extension was found to relate with active left internal rotation to 0.3076. Active left flexion was correlated with extension (0.3235), as was right passive adduction

(0.3383). Active extension on the left was related to two abduction with external rotation variables, active right (0.4215) and active left (0.4559). Active flexion with external rotation on the left was related to left active extension at the 0.3911 level. Active right extension was correlated to 0.4801 with left active. The numbers of years of training had a negative relationship, to the -0.3177 level, with active left extension.

TABLE 15 - EXTENSION CORRELATIONS WITH ADDUCTION AND INTERNAL ROTATION

Extension	Adduction	Level	Extension	Internal Rotation	Level
Right Passive	Left Active	0.5089	Right Active	Right Active	0.3015
Right Passive	Right Active	0.5198	Left Passive	Left Passive	0.3290
Right Passive	Left Passive	0.7282	Left Active	Left Active	0.3076
Right Active	Right Passive	0.3026			
Left Passive	Right Active	0.3032			
Left Passive	Left Passive	0.3677			
Left Passive	Right Passive	0.4564			
Left Active	Right Passive	0.3383			

ADDUCTION

Right passive adduction was found to correlate with fourteen variables greater than 0.3000 or less than -0.3000. Three extension variables were related to passive adduction on the right side. These were active right at 0.3026 and passive left, at 0.4564, and active left, at 0.3383. Passive flexion with eternal rotation on the left side was related at the 0.3063 level. Related to passive adduction also was right active internal rotation (0.3071). Active flexion on the left side was correlated at 0.3440. Abduction with external rotation, passively on the left side, was related to right passive adduction at the 0.4623 level. The three other adduction variables were found to related to passive right. These were active left (0.5354), passive left (0.5502) and active right (0.7214). Four variables related negatively to right passive adduction. The type of training was negatively correlated at -0.3171, while the DAD was related at -0.3410. The number of years of training was correlated negatively to right passive adduction (-0.4284), as was estimated discomfort (-0.5727).

Active adduction on the right side was reported to correlate with eleven variables. Two extension variables were found to relate, passive left (0.3032) and passive right (0.5198). Right active flexion with external rotation was correlated to the 0.4127 level. Active right and left abduction with external rotation were correlated with right active adduction, at the 0.3316 and 0.3007 levels, respectively. Three abduction variables were related to active adduction on the right side. These were active left (0.3177), passive right (0.7214) and passive left (0.7898). Active left adduction was correlated at the 0.8363 level to right active adduction. Right active adduction was negatively related to two variables, age (-0.3114) and estimated discomfort (-0.3622).

Left passive adduction was positively correlated with two extension variables. These were passive extension on the right (0.7282) and left (0.3677) sides. Also related to left passive adduction was left passive abduction with external rotation, at the 0.3227 level. The other three adduction variables were correlated at 0.5502 (passive right), 0.7898 (active right), 0.8363 (active left). Negatively correlated with left passive adduction were age (-0.3114) and estimated discomfort (-0.3622).

Active left adduction was correlated with passive right flexion with external rotation at the 0.3059 level. Left active abduction was also related (0.4311). Active left adduction was related to right passive extension at the 0.5089 level and to right passive abduction at the 0.5354 level. Active adduction on the left side was correlated with two other adduction measures, active right (0.7529) and passive left (0.8363). Left active adduction was negatively related to one variable, estimated discomfort.

TABLE 16 - ADDUCTION CORRELATIONS WITH ESTIMATED DISCOMFORT

ADDUCTION	LEVEL
Right Passive Adduction	-0.5727
Right Active Adduction	-0.3622
Left Passive Adduction	-0.3622
Left Active Adduction	-0.3500

INTERNAL ROTATION

Positive correlations with passive right internal rotation were found only with the three similar movements. Active left internal rotation was related at the 0.6253 level, while passive left was 0.7152. Active right internal rotation was related to passive right (0.7712). Flexion with external rotation passively on the left side was found to be negatively related to right passive internal rotation (-0.3590). Estimated discomfort was related at the -0.4749 level.

Active internal rotation on the right side was related to active right extension at the 03015 level, and right passive adduction at the 03071 level. The other internal rotation values were found to relate to active right, these were active left (0.6877), passive left (0.6925) and passive right (0.7712). Negatively correlated with right active internal rotation were pain at its worst (-0.3213) and estimated discomfort (-0.4215).

Left passive internal rotation was found to correlate with ten variables, seven positively and three negatively. Type of training, years of training, and the number of years a dancer had studied seriously were all found to relate positively to passive internal rotation on the left side (0.3084, 0.3315, 0.4162). Passive extension on the left side was related to left passive internal rotation at the 0.3290 level. Correlated to left passive were the other three internal rotation measurements, active right, passive right, and active left, at the 0.6925, 0.7152, and 0.9135 levels respectively. Passive (-0.3049) and active (-0.3161) abduction on the left side were found to negatively correlate with passive left external rotation. Also negatively related was passive flexion with external rotation on the left side (-0.4639).

Left active internal rotation was correlated with the number of years of training at the 0.3036 level. Related at the 0.3076 level was active left extension. The subjects estimate of their flexibility was correlated (0.3231). Active internal rotation on the left side was also related to the number of years of serious training the dancer had (0.3660). As seen previously, the internal rotation values were all correlated with left active. These were passive right (0.6253), active right (0.6877) and passive left (0.9235). Left active internal rotation was negatively correlated with two variables, left passive abduction (-0.3220) and left passive flexion with external rotation (-0.3999).

TABLE 17 - INTERNAL ROTATION CORRELATIONS WITH ESTIMATED DISCOMFORT

Internal Rotation Measure	Level
Passive	-0.3453
Active	-0.3249

DISCOMFORT MEASURES

EXPERIENCED DISCOMFORT

Whether a dancer had ever experienced discomfort at the hip, and the degree to which she had experienced discomfort was found to relate to thirteen variables. Seven of these variables correlated positively, while six correlated negatively. Right active external rotation was correlated with experienced discomfort at 0.3553. Experienced discomfort was also related to average degree of discomfort (0.4261). The degree to which hip discomfort affected dancing correlated at 0.5064 with experienced discomfort. Both pain experienced at its worst (0.5805) and its least (0.3520) were related to experienced discomfort. Experienced pain was negatively related to right passive (-0.4749) and active (-0.4215) internal rotation. Also negatively correlated with experienced pain were the four adduction variables, passive right (-0.5727), active right (-0.3852), passive left (-0.3622), and active left (-0.3500).

AVERAGE DEGREE OF DISCOMFORT

The average degree of discomfort was positively correlated to eighteen of the other pain measures. It was not correlated positively with any of the flexibility measures, but was negatively related to five. Estimated discomfort was related to average degree of discomfort at the 0.4261 level. Average degree of discomfort was also correlated with the degree to which the discomfort affected dancing (0.5420). Average degree of discomfort was correlated with the Pain Rating Index at 0.4542. Hip discomfort felt by the subjects related to average degree of discomfort at 0.4777 (pain at present), 0.8652 (pain at its worst), and 0.3847 (pain at its least). Both the total (0.6506) and partial (0.9348) pain scores were related to average degree of discomfort. Three external rotation measurements were negatively correlated with average degree of discomfort. These were passive right (-0.4215), passive left (-0.4501), and active left (-0.5282). Also negatively related were right passive (-0.3517) and right active (-0.3346) flexion.

DEGREE TO WHICH HIP DISCOMFORT AFFECTS DANCING

The degree to which hip discomfort affects dancing, as assessed by each subject was correlated with bi-iliac width at the 0.3638 level. Estimated discomfort was also correlated at 0.5064. Hip discomfort at present and at its worst were correlated at the 0.3898 and 0.5984 levels, respectively, with the degree to which hip discomfort affects dancing. Right passive adduction was negatively correlated with the degree to which hip discomfort affects dancing (-0.3702). Left passive and active abduction were also shown to relate, at -0.3118 and -.3405, respectively. Right passive flexion was correlated with the degree to which hip discomfort affects dancing at the -0.3399 level.

PAIN RATING INDEX

The Pain Rating Index was found to correlate with the years of training (0.3632) and the years of serious training (0.3606). The Pain Rating Index was negatively correlated with left passive abduction at -0.3163. Also related was the average degree of discomfort at 0.4542. Pain at present (0.4524), at its worst (0.5417) and its least (0.7190) were all correlated with the Pain Rating Index.

HIP DISCOMFORT AT PRESENT

Hip discomfort at the present time correlated with both the average degree of discomfort, at 0.5777, and the degree to which this discomfort affected dancing, at 0.3898. Both the Pain Rating Index (0.4524) and hip pain at its worst (0.5483) were related to hip discomfort at present.

HIP DISCOMFORT AT ITS WORST

Right active internal rotation (-.03212) was negatively related to hip discomfort at its worst. Also negatively correlated were left passive abduction (-0.3101), left active abduction (-0.3186), and right active abduction with external rotation (-0.3438). Estimated discomfort was related at 0.5805, as was average degree of discomfort, at 0.8652. The degree to which discomfort affected dancing was correlated with hip discomfort at its worst at the 0.5984 level. Both hip discomfort at present and at its least were related to discomfort at its worst. These were at 0.5483 and 0.3617, respectively.

HIP DISCOMFORT AT ITS LEAST

Hip discomfort at its least was related to sixteen variables. These were all positive relationships. The number or years of serious training was related to hip discomfort at its least at 0.4719. Both right passive (0.3367) and left active (0.3000) abduction with external rotation correlated with hip discomfort at its least. Also related was left active flexion with external rotation, at the 0.3802 level. Hip discomfort at its least was related to both estimated discomfort (0.3520) and the average degree of discomfort (0.3947). The Pain Rating Index was also found to relate to hip discomfort at its least (0.7190). Hip pain at its worst correlated with pain at its least at the 0.3617 level.

T-TESTS BETWEEN FLEXIBILITY GROUPS

T-Tests were performed between the moderately flexible group and the most flexible, moderately flexible and least flexible, moderately flexible and limits of flexibility (most and least flexible combined) and most flexible and least flexible to determine what significant differences, if any, existed the flexibility and discomfort measures between the groups. Results were recorded with $p \leq .05$ as significant. When $p \leq .01$ level appeared, it was recorded as more discriminate.

MODERATELY FLEXIBLE AND MOST FLEXIBLE

The moderately flexible group and most flexible group were compared for passive external rotation. The difference between fifty five degrees (moderately) and seventy two degrees (most) was found to be significant at the $p \leq 0.01$ level when a t-test was performed. Similarly, the difference between the moderate mean of fifty one degrees and the most mean of sixty six degrees for active external rotation was found to be important ($p \leq 0.01$ level). Passive internal rotation was significant as the $p \leq 0.05$ level (moderate-thirty degrees, most-twenty four degrees). Significance at the $p \leq 0.05$ level was determined for passive abduction, where the most flexible group had a mean of forty five degrees and the moderately flexible group had a mean of fifty three degrees. The moderately flexible group had a reported mean of one hundred and thirty one degrees for passive flexion, while the most flexible group had a mean of one hundred and sixty one degrees. This difference was significant at the $p \leq 0.01$ level. Also significant ($p \leq 0.01$) was flexion with external rotation, where the moderate mean was one hundred and thirty six degrees and the most mean was one hundred and sixty two degrees. When the average degree of hip discomfort was compared between the two groups, the result was important at $p \leq 0.05$ (moderately at forty five, most at twenty five). The flexibility score, upon which the two groups were determined was significant at $p \leq 0.01$ (moderate mean score 1.0, most mean score 1.25).

MODERATELY FLEXIBLE AND LEAST FLEXIBLE

An significant ($p \leq 0.01$) difference was discovered between the years of training in the moderately flexible and least flexible groups. The moderately flexible subjects had studied an average of eleven years, while the least flexible had trained an average of thirteen years. The differences in bi-iliac width (moderately - twenty one centimeters, least - twenty three centimeters) were significant at the $p \leq 0.01$ level between the two groups. Passive internal rotation, where the moderate mean was thirty degrees and the least mean was thirty eight degrees, was significantly different at $p \leq 0.01$. Active internal rotation was also significant ($p \leq 0.01$) with a moderate mean of twenty three degrees and the least mean at thirty one degrees. Significant differences were reported for both passive and active abduction. The moderately flexible passive mean was fifty three degrees, while the least flexible group passive mean was forty six degrees ($p \leq 0.01$). The Active means for abduction were forty seven degrees (moderate) and forty one degrees (least), $p \leq 0.05$ level for significance. When examining abduction with external rotation, a significant difference ($p \leq 0.01$) was found between the moderate mean of one hundred and sixty four degrees and the least average of one hundred and fifty one degrees. The moderately flexible group had a mean score of 12 on the Pain Rating Index, while the least flexible group reported a mean of 22. This was significant at the $p \leq 0.05$ level. The flexibility scores were significant at $p \leq 0.01$ (moderate-1.0, least-0.76).

MODERATELY FLEXIBLE COMPARED TO THE LIMITS OF FLEXIBILITY

Six measures were found to be significantly different between the moderately flexible group and the group which combined the most and least flexible (Limits) when T-Tests were performed. The number of years of training was significantly ($p \leq 0.05$) different between the moderately flexible group (11 years) and the limits group (12 years). Both passive ($p \leq 0.05$) and active ($p \leq 0.05$) external rotation were significantly different. The passive mean for the moderate group was fifty five degrees, while the limit group had an average of sixty three degrees. For active external rotation, means of fifty one degrees (moderate) and fifty seven degrees (limits) were reported. Abduction measures were also significant for both passive (moderate-fifty three degrees, limits-forty five degrees) and active (moderate-forty seven degrees, limits- forty two degrees) movements. Passive flexion averages were reported at one hundred and thirty two degrees for the moderate group, and at one hundred and forty five degrees for the limits group. This was significant at the $p \leq 0.01$ level.

MOST FLEXIBLE COMPARED TO LEAST FLEXIBLE

The most significant differences were found between the most flexible and least flexible group. The number of years of training was significantly ($p \leq 0.05$) different, as the most flexible group reported a mean of eleven years, while the least flexible reported an average of thirteen years. Differences were found in the subjects own estimate of their flexibility. The most flexible mean was sixty three, while the least was fifty, significant at $p \leq 0.05$. Bi-iliac width differences between the most (20 cm) and the least (23 cm) were significant. Passive external rotation differences were significant at the $p \leq 0.01$ level, where the mean for the most flexible was seventy two degrees and the least was fifty four degrees. Active external rotation was found to be significantly different ($p \leq 0.01$) between the two groups (most-sixty six degrees, least-fifty degrees). Means were found to be twenty four and twenty one degrees for passive and active internal rotation for the most flexible group. These means were thirty eight and thirty one degrees for the least flexible group, giving the averages a significant difference of $p \leq 0.01$. The most flexible group had an average of one hundred and sixty eight degrees for abduction with external rotation, while the least flexible group had a mean of one hundred and fifty one degrees. This was significantly different at $p \leq 0.01$. Passive flexion was different ($p \leq .01$) between the two groups, where the most mean was one hundred and sixty one degrees and the least mean was one hundred and thirty one degrees. Passive flexion with external rotation (most- one hundred and sixty two degrees, least- one hundred and thirty degrees) was also significance ($p \leq 0.01$). Differences between reported means for estimated discomfort were significant ($p \leq 0.05$), where the average was two (frequent hip discomfort) for the most flexible group and one (occasional hip discomfort). However, the most flexible group reported a significantly ($p \leq 0.05$) lower average degree of discomfort (twenty five) than the least flexible group (forty nine). Results of the Pain Rating Index were also significantly ($p \leq 0.05$) different between the two groups, with the most reporting nine and the least reporting twenty two. As expected, the flexibility scores were different at $p \leq 0.01$, where the most flexible mean was 1.25 and the least was 0.76. A significant ($p \leq 0.05$) difference was detected between the strength score of the most flexible group (1.1) and the least (0.89).

DISCUSSION

The results of any study do not have complete meaning unless they are compared to the work of previous researchers. Also essential for full understanding of the results is the context in which they are important: how they relate to the dancer.

AGREEMENT WITH PREVIOUS FINDINGS

Passive Flexibility Measures

Passive measurements in this study generally agreed with work previously done by LeGreci-Mangini (1994) and Reid (1990). External rotation, extension, and abduction means were consistent with the findings of LeGreci-Mangini (1994). However, the values for flexion did not agree with either Reid (1988) or LeGreci-Mangini (1994), most likely due to the differences in methodology. LeGreci-Mangini (1994) measured flexion with the contralateral knee flexed, and Reid (1990) measured with both knees flexed. In the case of this study, both knees were extended to better simulate the subjects movement while dancing. Reid et al (1990) used the contralateral leg as a way of stabilizing the pelvis. However, the range of motion that a dancer is able to achieve is highly affected by the flexion of both knees. Flexion at the knees allows the dancer to achieve a much greater range of motion. Whether in class or on the stage, dancers very seldom are allowed to flex their knees in these type of movements. LeGreci-Mangini improved upon this methodology by having the knee of the working leg extended. However, the same problem still exists, the dancer must have both knees extended the vast majority of the time. Methodology in this study used both knees extended to provide for measurement of the most realistic and challenging circumstance related to the dancers' experience. However, the problem of pelvic and lumbar stability is a valid one. The researchers in this study (Covlin, 1995) measured subjects while standing (as they are during dance) but against a wall. This allowed the researcher to monitor movements of the pelvis and lumbar spine and to only measure range of motion prior to compensations in these areas.

TABLE 18 - COMPARISONS BETWEEN COVLIN (1995), LIGRECI-MANGINI (1994), and REID ET AL (1987) PASSIVE MEASURES

	Covlin, 1995				LiGreci-Mangini, 1994				Reid, 1987	
Measure	RIGHT		LEFT		RIGHT		LEFT			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	S D
External Rot Pass	56	11	60	10	61	6	59	5	-	-
Ext Rot Pass Sit	-	-	-	-	35	4	35	5	84	16
Internal Rot Pass	31	9	29	8	39	6	40	7	-	-
Int Rot Pass Sit	-	-	-	-	31	6	32	6	49	8
Extension Pass	26	5	29	6	28	5	27	4	-	-
Ext Pass KF	-	-	-	-	-	-	-	-	-0.4	1
Adduction Pass	17	5	17	12	12	3	12	3	-	-
Add Pass KF	-	-	-	-	-	-	-	-	-2	8
Abduction Pass	48	10	49	7	43	6	45	6	-	-
Abd Pass CKF*	-	-	-	-	-	-	-	-	55	7
Abd Ext Rot Pass	164	11	159	12	75	10	77	10	-	-
Flexion Pass	139	16	136	18	124	5	126	6	-	-
Flex Pass CKF *	-	-	-	-	132	5	135	5	-	-
Flex Pass KF **	-	-	-	-	-	-	-	-	167	7
Flex Ext Rot Pass	139	16	140	17	-	-	-	-	-	-

* Contralateral knee flexed
** Both knees flexed

Active Flexibility Measures

The active hip flexibility means supported findings by Miller et al .(1993). The means for hip extension fell well within the range established by Miller (1993), as did flexion and flexion with external rotation. No other active measures were taken by Miller et al. (1993).

Active range of motion in this study was smaller than those of the passive measures. Miller et al. (1993) also found their active measures to be less than the passive measures taken by Reid (1987). This is not a suprising result, as ballet dancers often have passive flexibility which far exceeds their strength capabilities. Moscov et al. (1994) found that while static (passive) flexibility in dancers was significantly increased over non dancers, this was not the case for dynamic (active) hip flexibility (hip flexion, extension, and hyperextension). Miller et al's (1993) research contradicted Moscov et al. (1994), they found that dancers did have greater active range of motion than nondancers. The researcher in the present study believes the work of Miller et al. (1993) to be correct, that dancers have a significantly increased range of motion at the hip than non dancers. This is directly attributable to the intense training of dancers and the tremendous emphasis placed on hip flexibility.

TABLE 19 - COMPARISONS BETWEEN COVLIN (1995) and
MILLER ET AL. (1993) ACTIVE MEASURES

	Covlin, 1995				Miller et al, 1993			
Active Measures	RIGHT		LEFT		RIGHT		LEFT	
	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev
Flexion	102	13	95	13	109	10	110	12
Flex Ext Rot	104	16	99	12	105	10	106	12
Extension	24	4	26	4	30	5	29	5
Ext Ext Rot	-	-	-	-	28	5	28	4

Measur [illegible] fferences: Miller et al's subjects were lying prone, while Covlin's subjects were standing for these [illegible]ments.

MARTYR SYNDROME

The "martyr" syndrome in dancers (as discussed in the literature review) may have influenced the results in two different ways. It was obvious to the researchers, through facial expression and body language, that some subjects were experiencing pain even though they reported none. Other dancers seemed to be eager to express "how much pain" they lived through for their art. Both these factors may have effected the results. Clearly, these factors pose a major challenge to the study of dancers; perhaps a longer study would help to get a more in-depth look at their pain experiences.

CORRELATION BETWEEN MEASURES FOR EACH RANGE OF MOTION

For each of the flexibility ranges of motion, four different measures were taken, passive right, active right, passive left and active left. These measures were correlated with each other to determine the relationship between passive and active measures, as well as between the right and left sides. The strongest positive relationships were determined between measures of both external rotation and internal rotation for all of the four measures. For the adduction range of motion, correlations showed a strong positive relationship. Both flexion and flexion with external rotation, when the four measures were compared, found positive relationships between measures, although the level of relationship was less than those for adduction, internal rotation, and external rotation. Abduction with external rotation correlations were found to have similar positive relationships. The measures for both extension and abduction were found to have only weak positive relationships, correlations were found only between active right and left, right passive and right active, and left passive and left active. These two measures, extension and abduction, had the least significant relationships between measures, but were found to be positive nonetheless. These correlations for flexibility range of motion showed clearly that each range of motion was related in the passive and active measures and on both sides of the body. These results allow the researcher to compare ranges between groups with the confidence that the measures were accurate to an acceptable degree and showed the importance of all four measures taken (right passive, right active, left passive, left active).

FLEXIBILITY AND THE EXPERIENCE OF PAIN

Hypothesis #1 stated that subjects who were highly flexible or highly inflexible would experience more pain. It was found that the average degree of discomfort experienced by the subjects was linked to their flexibility. The most flexible group was shown to have a significantly reduced score when compared to either the moderately flexible ($p< 0.05$) and least flexible ($p< 0.05$) groups. This is important because the severity of discomfort, as judged by the subjects, was much less in the most flexible groups than in other groups. When examining the Pain Rating Index results of the subjects, the least flexible group reported a significantly ($p\leq0.05$) increased score than for the moderately flexible, indicating that the word descriptors chosen were more severe. For the most flexible dancers, the PRI was significantly less ($p\leq0.05$) than for the least flexible. These results show that while the hypothesis that highly inflexible subjects would experience more pain was correct, this was not the case for highly flexible dancers. These subjects experienced less pain than those who were moderately flexible of highly inflexible.

BALLETIC RANGE OF MOTION COMPARED NON BALLETIC RANGES

It was hypothesized (#2) that as range of motion for external rotation, flexion, flexion with external rotation, abduction, abduction with external rotation, and extension increase, range of motion for internal rotation and adduction would decrease. There were several findings in this study that highlight the importance of this theory and its practical relationship to dancers flexibility.

It appears that passive abduction with external rotation, flexion, and flexion with external rotation are all indicators of an increased flexibility score. Further, active and passive abduction with external rotation, flexion, and flexion with external rotation are indicators of a high AROM score. This is important as the other flexibility measurements did not have this pattern. It is possible that these three indicators may help to pinpoint dance students who are more flexible.

Abduction with external rotation (second position) is an extremely important range of motion for the dancer. It was shown in this study that abduction with external rotation was also an important indicator of other ranges important to ballet. Both flexion and flexion with external rotation were correlated with abduction with external rotation in passive and active range (Table 13,14). There are many possible reasons for this relationship. Ballet may self select students who are strong in all three of these ranges. But more likely is the possibility that it is the training itself which promotes strength in the three areas.

Strengthening the Tensor Fasciae Latae, Gluteus Medius, and Gluteus Minimus muscles, which are involved in both flexion and abduction movements (Magee, 1992, Calais-Germain, 1993)(Appendix C), would promote increases in all of these ranges. Further, the heavy emphasis on stretching Biceps Femoris, Semimenbranosus, Semitendonisus while strengthening the muscles involved in flexion, abduction and external would contribute to muscular imbalances. It is the frequently found that ballet dancers have very strong but tight flexors, abductors, and external rotators of the hip, while having weak adductors and extremely flexible extensors.

Internal rotation range of motion was found to have a negative relationship with the other balletic ranges of motion, as shown by the significant differences between flexibility groups. While the most flexible group was significantly increased for external rotation, abduction with external rotation, flexion, and flexion with external rotation when compared to the moderately and least flexible groups, the most flexible group was significantly decreased in both passive and active internal rotation. Adduction, although hypothesized to share the same relationship to the other balletic ranges as internal rotation, was not statistically decrease as compared between groups.

Although the results of this study support the hypothesis that external rotation, flexion, flexion with external rotation, abduction, and abduction with external rotation bear an inverse relationship with adduction and internal rotation in ballet dancers, the relationship of hip extension range of motion with adduction and internal rotation appears to be quite different. Not only was the inverse relationship between extension and adduction and internal rotation not confirmed, it appears that these measures could, in fact, share a positive relationship. Correlations showed a positive relationship between extension and adduction ranging from weak (0.3032 - 0.4564) to stronger (0.5089 to 0.7282) (Table 15). Further, some weak positive correlations were found between extension and internal rotation. This becomes important when one considers that no positive correlations of 0.3000 were found between any extension variable and external rotation, flexion, or abduction. In fact, no negative correlations were apparent. These findings suggest that extension should not be grouped with the other balletic ranges of motion and may, after further study, be grouped with adduction and internal rotation. Further support for this theory comes from the t-tests performed between groups. Although significant differences were found between all of the other flexibility measures when comparing the most flexible to moderately flexible and to the least flexible, there were no significant differences in extension range of motion found between any of the groups. This suggests that extension does related to the other ranges of motion in a different way than originally hypothesized.

This study has shown that as external rotation, flexion, flexion with external rotation and abduction with external rotation increased, internal rotation decreases. The hypothesis was not confirmed for adduction. This study did not show that as extension increased, adduction and internal rotation decreased. Correlations suggested that it is possible that as extension increased, adduction and internal rotation increased. No relationship between abduction and the non balletic ranges were clear.

THE RELATIONSHIP BETWEEN RANGE OF MOTION AND BALLET TRAINING

Although the hypothesis that balletic ranges of motion and the range of motion for adduction and internal rotation share an inverse relationship was shown, the results of this study do not support the notion that these trends increase with age and training. Hypothesis #3 suggested a positive correlation between the balletic ranges of motion and training, while Hypothesis #4 stated that as training increased, internal rotation and adduction would decrease. Although Reid (1987) found that age and training further exemplified the muscular imbalance of flexibility and active flexibility, the correlations in this study are contradictory. Age was found to have a weak negative relationship with some abduction and abduction with external rotation measures. Further, the years of training were positively correlated with internal rotation but showed a weak negative relationship to abduction, abduction with external rotation, and flexion. Serious years of training was shown to have similar relationship with abduction with external rotation, where a stronger negative correlation was found. Internal rotation was again shown to have a stronger positive correlation with serious years of training than with the years of training. These correlations, although not conclusive, suggest that the flexibility imbalances found in younger dancers do not necessarily increase with time and training. However, it is important to recognize that these findings may not be a result of the inherent relationships between training and flexibility, they may in fact be influenced by the particular group of subjects. It is possible that the younger dancers were more flexible for reasons other than training than the older dancers with more training. This must be considered as a possibility, as training is carefully designed to increase both passive and active flexibility. These relationships require further study. The results of this study have shown that the increase of balletic ranges and decrease of non balletic ranges does not necessarily increase with training.

CORRELATIONS BETWEEN BALLETIC RANGES OF MOTION AND BETWEEN NON BALLETIC RANGES

Hypothesis #5 stated there would be positive correlations found between each of the balletic ranges of motion and between each of the non balletic range of motion. Correlations between the balletic ranges of motion, external rotation, flexion, flexion with external rotation, and abduction with external rotation showed important relationships between the measures. Although the correlations were in some cases weak positive relationships, these results indicated that the balletic ranges did in fact increase together. Moderate and strong positive relationships were found between abduction with external rotation and the two flexion measures, flexion and flexion with external rotation. Neither abduction, without external rotation, nor extension were found to have positive correlations with the other balletic ranges. In some cases, weak negative correlations were found with abduction. None were significantly important to draw a conclusion. For the non balletic ranges of adduction and internal rotation, there were no correlations above 0.3000 or below -0.3000. There relationship between these variables is unclear. This study has shown that external rotation, flexion, flexion with external rotation, and abduction with external rotation had positive correlations to each other. Positive correlations between adduction and internal rotation were not confirmed.

THE RELATIONSHIP BETWEEN ADDUCTION, INTERNAL ROTATION AND PAIN EXPERIENCES

It was hypothesized (#6) that as internal rotation and adduction range of motion decreased, hip discomfort would increase. Correlations which signified a negative relationship were found relating internal rotation and adduction to estimated discomfort the dancer had experienced. Although these correlations showed only a weak (-0.3410) to moderate (-0.5272) negative relationships, these possible relationships lead the researchers to examine estimated discomfort and the differences of this measure between the most, moderate, and least flexibility groups. These differences, examined by t-tests, showed significant differences in the estimated discomfort of the most flexible and least flexible groups ($p \leq 0.05$). The correlations and t-tests suggest that decreases in internal rotation and adduction may be related to an increase in estimated discomfort .

Estimated discomfort was negatively correlated to both active and passive adduction (Table 16). This confirms the previous studies of Jacobs & Young (1978) and Reid et al (1987) that increasing the dancers range of motion in adduction can decrease the incidence of hip injury. A similar finding (Table 17) was shown with passive internal rotation, as supported by Reid (1988). "This unbalanced flexibility (decreased internal rotation) may play a role in lateral knee and anterior hip pain" (Reid, 1988). This finding was not confirmed in the active range for internal rotation.

This study confirms that both decreased internal rotation and adduction lead to an increased experience of discomfort. While these findings support Reid et al (1987), there were several measurements which were in contrast. This study showed that active adduction did decrease with the years of training, but internal rotation, active and passive, increased with years of training. This may be due to the fact that dance teachers are increasingly aware of muscle imbalances. It is also possible that the dancers are increasing their internal rotation due to participation in modern classes, which at the present time have become vastly more popular with ballet dancers than they were ten years ago.

The results of this study confirm the earlier work of Reid et al (1987) that decreased range of motion for both adduction and internal rotation are related to increased discomfort at the hip

BI-ILIAC WIDTH AND FLEXIBILITY

It was hypothesized (#7) that as bi-iliac width increased, flexibility would decrease. In this study, bi-iliac width, the distance between the anterior superior iliac spines, was correlated with several of the passive ranges of motion important to ballet dancers. Passive flexion, flexion with external rotation and abduction with external rotation were all negatively correlated with bi-iliac width. Although the reasons for this correlation can not be determined within the scope of this study, it is important to note that the weak negative relationships shown may be important. The increased flexibility ranges of the dancers with smaller bi-iliac widths resulted in significantly different bi-iliac width measures between the most, moderate, and least flexible subjects ($p \leq 0.01$). These relationships between passive flexibility and bi-iliac width show an important trend and give possible support to the traditional notion that ballet dancers should have a slender bi-iliac width. However, before this theory is made conclusive, further work must be done to show if these weak to moderate correlations and strong t-test results are in fact the result of bi-iliac width and not another factor which is as yet undetermined.

Bi-iliac width was also related to the flexibility score. As the bi-iliac width increased, the flexibility score decreased. There are a variety of possible reasons for this finding. With increasing bi-iliac width, the position of the acetabulum moves more laterally. While skeletal this may seem to be an advantage to dancers, the changes in muscular attachment are not beneficial. As the bi-iliac width increased and the acetabulum moved laterally the distal muscle attachments are farther away from the proximal attachments than in those individuals with a smaller bi-iliac width. In dancers with a larger bi-iliac width, this puts the muscles in an already stretched position, thereby limiting the amount of stretch possible (Dr. Robert Steadward, Personal Communication, November 15th, 1995). Dancers with a greater bi-iliac width would therefore have more adduction range of motion, but less abduction range of motion. Dancers with smaller bi-iliac widths would have greater possibilities for motion for abduction, essential to the dancers success. However, this is not the entire extent of the relationship, because this study will show that ample range of motion for adduction is important in reducing pain, but it was the most flexible dancers, with the smallest bi-iliac widths which experienced the least pain. Perhaps the muscular attachments affected by bi-iliac width show that adduction range of motion is more easily increased by dancers than abduction range of motion.

The moderately flexible group was shown to have a significantly ($p \leq 0.01$) smaller bi-iliac width than the least flexible group, and the most flexible group was even smaller ($p \leq 0.01$). Correlations in this study also showed the bi-iliac width to correlate with passive abduction with external rotation, flexion, and flexion with external rotation. These ranges are of primary importance to the dancers career. The results of this study have shown that dancers with a small bi-iliac width have increased range of motion for flexion, flexion with external rotation, and abduction with external rotation and the decreased bi-iliac width of the most flexible group was statistically significant.

BI-ILIAC WIDTH, FLEXIBILITY AND HIP DISCOMFORT

Hypothesis #8 stated that as bi-iliac width increased and flexibility decreased, hip discomfort would increase. Bi-iliac width was also found to positively relate to the degree discomfort affected dancing. Both Jacobs & Young (1978) and Reid (1988) discussed the theory that subjects with a narrow bi-iliac width are prone to injury as a result of an increased angle of inclination of the femoral neck. Jacobs and Young (1978) found that decreased bi-iliac widths were related to an increase in the snapping hip syndrome, which is often painful. They theorized that "this increased angle of inclination could contribute to a possible muscular imbalance between the hip abductors and adductor." (Jacobs & Young, 1978). Reid (1988) discussed his earlier study (1987) and the importance of this imbalance to the snapping at the hip. He stated that the study made "a significant

Young, 1978). Reid (1988) discussed his earlier study (1987) and the importance of this imbalance to the snapping at the hip. He stated that the study made "a significant correlation between the presence of hip and knee symptoms and tightness in the abductor muscles and iliotibial band". (Reid, 1988). This study does not support the finding that bi-iliac width contributes to the snapping hip syndrome, in fact no relationship between bi-iliac width and snapping hip was clear. A weak positive correlation was found between bi-iliac width and the degree to which discomfort affected dancing, however, there were no other correlations linking bi-iliac width to discomfort. Significant differences ($p \leq 0.01$) between the bi-iliac width of the flexibility groups can also be compared to differences ($p \leq 0.05$) in PRI and estimated discomfort, and average degree of discomfort. The reasons for these relationships are unclear, but this study has shown that increased bi-iliac width and decreased flexibility lead to an increased incidence of hip discomfort.

CONCLUSION

Flexibility or range of motion at the hip joint is extremely important to a dancer's career, especially a ballet dancer. "Though all dance techniques utilize a turned out position of the legs to a greater or lesser degree, classical ballet is based on the turnout; without it, the technique cannot exist. The well turned out leg makes a fundamental contribution to the stability, range of motion, mobility and strength of the dancer, as well as to the elongated shape of the muscles" (Grieg, 1994). Yet very little is known about the effects of reduced flexibility on the dancers rate of injury. Previous authors, such as Reid et al (1987), Kushner et al (1990), Miller et al (1993), and Legreci Mangini (1994), have attempted to study the relationship of hip flexibility to the incidence of pain or injury. Reid et al (1987) stated that the longer a dancer studies, the more likely she is to suffer some type of injury. Reid hypothesized that the older a dancer is (the longer she had studied), the more flexible she would be in the balletic ranges, and the less flexible she would be in internal rotation and adduction.

> "It was noted that the overall flexibility pattern seen in the dancer populations (ie. increased external rotation, flexion, abduction, knee extension and decreased hip adduction and internal rotation) was even more exaggerated in the older ballet dancers. This was especially true of the relative inflexibility in passive hip adduction." (Reid et al, 1987)

These attempts have shown the great need for further study. This research combined Leighton Flexometer measures, the McGill Pain Questionnaire and the Visual Analogue Scale to examine the relationship between pain and flexibility.

The most significant differences found in this study between the flexibility groups were in three key areas: external rotation, bi-iliac width, and pain measures. These findings, although they do not provide evidence of a conclusive nature regarding the relationship between flexibility and pain, do provide important insights into relationships which need further study.

Although it was hypothesized that subjects at either end of the flexibility continuum would be a greatest risk for hip discomfort, the study indicated that the less flexible dancers experienced the most hip pain. Of the twenty four female subjects, the five most flexible dancers were, in fact, at the least risk for pain. Therefore, hypothesis #1 was not supported.

An important finding of this study, and supported by Reid et al (1987), was the fact that as external rotation, flexion, extension, and abduction increase, there is a decrease in internal rotation (Hypothesis #2). However, this was not confirmed for adduction.

Hypothesis #3 stated that there would be a positive correlation between the balletic ranges of motion, external rotation, flexion, flexion with external rotation, abduction, abduction with external rotation and extension and the years of ballet training. This hypothesis was not supported as correlations indicated that these measures actually decreased with training. Hypothesis # 4 stated that a negative correlation would be found between adduction, internal rotation, and years of ballet training. In fact, this study found an increase in range of motion for internal rotation with increased years of training. Thus, the hypothesis was not supported with the data. Adduction range of motion was not found to relate to years of training.

It was hypothesized (#5) that the balletic ranges would correlate with each other, as would the non balletic ranges. This study showed positive correlations between external rotation, flexion, flexion with external rotation, and abduction with external rotation, confirming the hypothesis. Abduction was not confirmed and appeared not to relate to the other balletic flexibility ranges. Extension contradicted the hypothesis and was correlated with both adduction and internal rotation. Adduction and internal rotation were not shown to correlate with each other.

The hypothesis (#6) that pain would increase as adduction and internal rotation decreased was confirmed. Also reported was the importance of the bi-iliac width. Hypothesis #7, that as bi-iliac width increased, flexibility would decrease was confirmed. It was further hypothesized (#8) that increased bi-iliac width and decreased flexibility would correspond to an increase in hip discomfort. This was shown to be correct.

It is important that the dance community consider the implications of training. This study lends support to the idea that the anatomical abilities of a dancers body are important in preventing injury. Dance teachers should be aware that students who push beyond their anatomical capabilities will put themselves at increased risk. Secondly, dance teachers should implement a balanced routine of stretching in their classes, where the adductor and internal rotation muscles are both stretched and strengthened. By combating ballet dancers muscles imbalances, the teacher can help his/her students to avoid injury and become stronger dancers.

FURTHER RESEARCH RECOMMENDATIONS

Further studies may wish to examine the repetitiveness of ballet. It is possible that the repetition of movements over and over may cause more pain in some dancers than the execution of a movement one time. In dance, and especially ballet, a dancer is required to complete a movement several hundred thousand times over the course of their training. The grande plie, for example involves flexion at the hip, knee, and ankle. This movement is repeated many times during one class, and is used in each and every class the dancer takes. While one grande plie may not be problematic, the high number of repetitions may be cause for concern. The results of this study may have been different if the dancers had been asked to do sixteen grande battement before filling out the VAS, instead of just one. Clicking or snapping of the hip tends to become more noticeable at the end of many repetitions. It is possible that this may be the case for many painful syndromes.

Also recommended for future research is the use of medical personnel to diagnose and grade the severity of hip injuries found in the dancers. If one could identify the exact causes of pain, the information may be extremely useful in avoiding injury. Similarly, in depth knowledge of the dancer's pain experience would aid the researcher in gaining insight into dance injuries. Further study could follow dancers over a season to determine which factors in a wide range of possible causes contributed to hip injury. Studies are also needed to examine the male dancer and the relationship between hip flexibility and injuries in that population. A large sample study is essential for determining the true nature of the relationship between hip flexibility and hip discomfort.

Another important recommendation is a confirmation study. The relationships examined in this work need to be confirmed with another study of similar size or by a large sample study. Although this would be a challenge for the researcher, it would provide more statistical power with which to base conclusions. Also of importance would be a study of the professional dance population to compare with this study of pre-professionals.

Appendix A

Informed Consent Form

Project Title: Hip Flexibility and Its Relationship to Hip Discomfort in Female Ballet Dancers.
Investigator: Tina Covlin, 431-2902, 11135-71 Avenue, Edmonton
Dr. Marsha Padfield, 492-1030, University of Alberta

Purpose: The purpose of the research project is to examine the relationship between hip flexibility and hip discomfort. Should a relationship exist, it is hoped that the information will be useful in the development of improved training methods that might decrease the incidence of hip injuries in ballet dancers.

Subject Involvement: Each subject will have her hip flexibility measured while executing a variety of movements. Subjects will then assess their experience of discomfort in the hip area through a questionnaire and balletic movements which may be videotaped from the neck down. The videotape will be used only to supplement the researcher's understanding of the data. It will not be included in the final project, nor will it be shown or used in any other way. At the conclusion of the study the videotape will be destroyed. Your involvement will last approximately thirty to forty-five minutes.

Confidentiality: All information gained from the study will be treated confidentially by the researcher. Subjects will be assigned an identification number and every effort will be made to ensure the subjects anonymity.

The research will be included in a Master's Thesis and the results will be made available to all participants. Although there are no direct benefits to the subject, the study may result in changes in training and injury prevention, which would benefit the dance community.

I, ______________________________, hereby agree to participate as a volunteer in the above named project.

I understand that there should be no health risks to me resulting from my participation. I understand that I am free to withdraw from the study at any time without penalty.

______________________________	______________________________
Subject's signature	Researcher's Signature
______________________________	______________________________
Guardian (if under 18 years)	Date

Part I - Personal Information

Age: ________ Sex: _____ Number of years ballet training: _____

Numbers of years of serious training (5+ hours per week): ________

Dominant method of ballet training: (ex. Cecchetti, RAD, Vagnova, Non-Syllabus): _________________________

Please identify your estimate of your flexibility at the hip using the following scale:

|---|

Not at all Flexible Extremely Flexible

External Rotation Supine

Passive R _______ L _______
Active R _______ L _______

Internal Rotation

Passive R _______ L _______
Active R _______ L _______

Extension Prone

Passive R _______ L _______
Active R _______ L _______

Adduction On Side

Passive R _______ L _______
Active R _______ L _______

Abduction Standing

Passive R _______ L _______
Active R _______ L _______

Abduction with External Rotation Standing

Passive R _______ L _______
Active R _______ L _______

Flexion Standing

Passive R _______ L _______
Active R _______ L _______

Flexion with External Rotation Standing

Passive R _______ L _______
Active R _______ L _______

Part III - Hip Discomfort Assessment

The following questionnaire is designed to assess the type of hip pain you may have experienced during your dancing career. Feel free to answer each question fully based on your own experiences. You may have never experienced pain in this region. Or it may be something you live with everyday.

Please read each question carefully.

1. Have you ever experienced discomfort in the hip region related to dancing?

___ no
___ yes, occasionally
___ yes, frequently
___ yes, constantly

2. Please indicate the average degree of discomfort you have experienced:

|--|

No discomfort   Extreme Discomfort

3. Please indicate the degree to which hip discomfort has affected your dancing

___ not at all
___ minimally
___ considerably
___ extremely

4. Where is your Pain? Please indicate with a dot the place(s) where you have experienced hip discomfort. Place an E beside dots where the discomfort was external, an I for internal, or EI for both.

5. Please indicate the degree of discomfort in the hip region when you perform the following movements to your maximum capability:

A. Grand Battement Devant from Fifth (sideways to camera)

Right Leg |--|
No Discomfort Extreme Discomfort

Left Leg |--|
No Discomfort Extreme Discomfort

B. Grand Battement Second from Fifth (facing camera)

Right Leg |--|
No Discomfort Extreme Discomfort

Left Leg |--|
No Discomfort Extreme Discomfort

C. Ronde de Jambe en l'air en de hors from devant to second (facing the camera)

Right Leg |--|
No Discomfort Extreme Discomfort

Left Leg |--|
No Discomfort Extreme Discomfort

D. Ronde de Jambe en l'air en d'hor from second to derriere (sideways)

Right Leg |--|
No Discomfort Extreme Discomfort

Left Leg |--|
No Discomfort Extreme Discomfort

E. Ronde de Jambe en l'air en de dans from derriere to second (facing camera)

Right Leg |--|
No Discomfort Extreme Discomfort

Left Leg |--|
No Discomfort Extreme Discomfort

F. Ronde de Jambe en l'air en de dans from second to devant (Sideways)

Right Leg |---|
No Discomfort Extreme Discomfort

Left Leg |---|
No Discomfort Extreme Discomfort

6. What does your discomfort feel like? please use the words below to describe the discomfort you have felt in the last week. Circle only those words that best describe it. Choose only the best word in each category and leave out any category that is not suitable.

Flickering Quivering Pulsing Throbbing Beating Pounding	Jumping Flashing Shooting	Pricking Boring Drilling Stabbing Lancinating	Sharp Cutting Lacerating
Pinching Pressing Gnawing Cramping Crushing	Tugging Pulling Wrenching	Hot Burning Scalding Searing	Tingling Itchy Smarting Stinging
Dull Sore Hurting Aching Heavy	Tender Taut Rasping Splitting	Tiring Exhausting	Sickening Suffocating
Fearful Frightful Terrifying	Punishing Grueling Cruel Vicious Killing	Wretched Blinding	Annoying Troublesome Miserable Intense Unbearable
Spreading Radiating Penetrating Piercing	Tight Numb Drawing Squeezing Tearing	Cool Cold Freezing	Nagging Nauseating Agonizing Dreadful Torturing

Are there any other words which you would add that express your discomfort?

____

7. When you experience discomfort, what kinds of things relieve your pain?

8. When you experience discomfort, what kinds of things increase your pain?

The following words represent the intensity of your discomfort. They are:

0	1	2	3	4	5
None	Mild	Discomforting	Distressing	Horrible	Excruciating

To answer the Questions below, use the number of the most appropriate word in the space beside each question.

9. Which word describes your hip discomfort right now? ____

10. Which word describes your hip discomfort at its worst? ____

11. Which word describes your discomfort at its least? ____

Appendix B

Correlation Tables

The following variables will be correlated:

Passive external rotation Right	ERPR
Passive External Rotation Left	ERPL
Active External Rotation Right	ERAR
Active External Rotation Left	ERAL
Passive Flexion Right	FPR
Passive Flexion Left	FPL
Active Flexion Right	FAR
Active Flexion Left	FAL
Passive Flexion with External Rotation Right	FERPR
Passive Flexion with External Rotation Left	FERPL
Active Flexion with External Rotation Right	FERAR
Active Flexion with External Rotation Left	FERAL
Passive Abduction Right	AbPR
Passive Abduction Left	AbPL
Active Abduction Right	AbAR
Active Abduction Left	AbAL
Passive Abduction with External Rotation Right	AbERPR
Passive Abduction with External Rotation Left	AbERPL
Active Abduction with External Rotation Right	AbERAR
Active Abduction with External Rotation Left	AbERAL
Passive Adduction Right	AdPR
Passive Adduction Left	AdPL
Active Adduction Right	AdAR
Active Adduction Left	AdAL
Passive Extension (Hyperextension) Right	EPR
Passive Extension Left	EPL
Active ExtensionRight	EAR
Active Extension Left	EAL
Passive Internal Rotation Right	IRPR
Passive Internal Rotation Left	IRPL
Active Internal Rotation Right	IRAR
Active Internal Rotation Left	IRAL
Subjects Estimate of Flexibility	ED
Average Degree of Discomfort	ADD
Affect on Dancing	DAD
Magill Pain Rating Index	PRI
Hip Discomfort Presently	HDP
Hip Discomfort Worst	HDW
Hip Discomfort Least	HDL

APPENDIX C

Muscles involved in Movement at the Hip

FLEXION	Psoas Iliacus Rectus Femoris Tensor Fasciae Latae Gluteus Minimus (ant) Gluteus Medius (ant) Sartorius Pectinius Gracilis	EXTENSION	Gluteus Maximus Biceps Femoris (long) Semimembranosus Semitendonsus Gluteus Medius (post) Adductor Magnus
ABDUCTION	Gluteus Medius Gluteus Minimus Tensor Fasciae Latae Gluteus Maximus (sup) Piriformis Obturators Gemelli Sartorius	ADDUCTION	Adductor Magnus Adductor Longus Adductor Brevis Pectinius Gracilis Psoas Iliacus Biceps Femoris (long) Gluteus Maximus
MED ROTATION	Gluteus Medius Gluteus Minimus Tensor Fasciae Latae	LAT ROTATION	Gluteus Maximus Deep Rotators Adductors

after Magee (1992) and Calais-Germain (1993)

APPENDIX D
CORRELATION TABLE SUMMARY

.3805	Age-Years	-.3114	Age-AdPL	.3553	ERAR-ED	-.3423	ERAR-FSRL
.4288	Age-Train	-.3384	Age-RFSL	.3807	ERAR-AbERPR	-.4679	ERAR-GDL
		-.3770	Age-AbERPL	.4749	ERAR-Flex		
		-.4016	Age-AbPL	.5523	ERAR-FPR		
		-.4148	Age-AbAl	.7120	ERAR-ERPL		
				.7192	ERAR-ERAL		
.3036	Years-IRAL	-.3142	Years-AbERPR	.8279	ERAR-ERPR		
.3138	Years-PRI	-.3145	Years-AbAL				
.3315	Years-IRPL	-.3177	Years-EAL	.3370	ERPL-FERPl	-.3544	ERPL-AbAR
.3605	Years-BIW	-.3263	Years-AdAP	.5018	ERPL-FPR	-.3654	ERPL-AbPR
.3632	Years-PRI	-.3311	Years-FERPR	.5801	ERPL-Flex	-.3875	ERPL-Pain S.
.5577	Years-S.Years	-.3319	Years-FERAR	.7120	ERPL-ERAR	-.4501	ERPL-ADD
		-.3916	Years-AbERPL	.7945	ERPL-ERPR		
		-.4009	Years-AbERAR	.8652	ERPL-ERAL		
		-.4284	Years-AdPR				
				.3198	ERAL-EbERPR	-.3002	ERAL-AbAR
.3183	S.Years-BIW	-.3277	S.Years-AbERPL	.3863	ERAL-FAR	-.3096	ERAL-GDL
.3606	S.Years-PRI	-.3397	S.Years-AbERAL	.4021	ERAL-Flex	-.3915	ERAL-AbPR
.3660	S.Years-IRAL	-.3621	S.Years-AbAL	.4676	ERAL-FERPR	-.4502	ARAL-Pain S.
.4162	S.Years-IRPL	-.4932	S.Years-AbERAR	.5527	ERAL-FPR	-.5383	ERAL-ADD
.4719	S.Years-HDL			.7192	ERAL-ERAR		
				.8652	ERAL-ERPL		
				.8851	ERAL-ERPR		
.3084	Train-IRPL	-.3117	Train-GSR	.6253	IRPR-IRAL	-.3590	IRPR-FERPL
.4288	Train-Age	-.3171	Train-AdPR	.7152	IRPR-IRPL	-.4749	IRPR-ED
.4507	Train-Flex	-.3419	Train-AbERAL	.7712	IRPR-IRAR		
		-.3749	Train-AbERAR				
		-.4466	Train-FERAL	.3015	IRAR-EAR	-.3212	IRAR-HDW
		-.4492	Train-FAL	.3071	IRAR-AdPR	.4215	IRAR-ED
		-.5790	Train-EAR	.6877	IRAR-IRAL		
				.6925	IRAR-IRPL		
.3231	Flex to IRAL			.7712	IRAR-IRPR		
.3414	Flex to FPR						
.3674	Flex to ERPR			.3084	IRPL-Train	-.3049	IRPL-AbPL
.4021	Flex-ERAL			.3290	IRPL-EPL	-.3161	IRPL-AbAL
.4501	Flex-Train			.3315	IRPL-Years	-.4639	IRPL-FERPL
.4749	Flex-ERAR			.4162	IRPL-S.Years		
.5801	Flex-ERPL			.6925	IRPL-IRAR		
				.7152	IRPL-IRPR		
.3605	BIW-Years	-.3138	BIW-FERPL	.9135	IRPL-IRAL		
.3183	BIW-S.Years	-.3155	BIW-FPL				
.4120	BIW-DAD	-.3250	BIW-AbERPR	.3036	IRAL-Years	-.3220	IRAL-AbPL
		-.3907	BIW-RBSR	.3076	IRAL-EAL	-3999	IRAL-FERPL
		-.4153	BIW-FERPR	.3184	IRAL-Pain S.		
		-.5176	BIW-AbERPL	.3231	IRAL-Flex		
		-.5355	BIW-FPR	.3660	IRAL-S. Years		
				.6253	IRAL-IRPR		
.3189	ERPR-FERAL	-.3512	ERPR-GDL	.6877	IRAL-IRAR		
.3674	ERPR-Flex			.9135	IRAL-IRPL		
.4139	ERPR-FERPL						
.4785	ERPR-FERPR			.3196	EPR-EAR		
.7945	ERPR-ERPL			.3470	EPR-RFSL		
.8297	ERPR-ERAR			.3496	EPR-RSBR		
.8851	ERPR-ERAL			.4840	EPR-EPL		
				.5089	EPR-AdAL		
				.5198	EPR-AdAP		
				.7282	EPR-AdPL		

.3015	EAR-IRAR	-.5890	EAR-Train	.7254	AbPR-AbAR	-.3654	AbPR-ERPL
.3026	EAR-AdPR					-.3915	AbPR-ERAL
.3196	EAR-EPR						
.3659	EAR-AbERAL			.7254	AbAR-AbPR	-.3002	AbAR-ERAL
.3665	EAR-FAR					-.3544	AbAR-ERPL
.4116	EAR-FERAL						
.4118	EAR-AbERPR			.7727	AbPL-AbAL	-.3049	AbPL-IRPL
.4801	EAR-EAL					-.3101	AbPL-HDW
.4803	EAR-FERAR					-.3163	AbPL-PRI
.5173	EAR-FAL					-.3220	AbPL-IRAL
.6124	EAR-AbERAR					-.4016	AbPL-Age
.3032	EPL-AdAP	-.3128	EPL-GSL	.3177	AbAL-AbAR	-.3145	AbAL-Years
.3290	EPL-IRPL	-.3183	EPL-GSR	.3302	AbAL-GDR	-.3161	AbAL-IRPL
.3677	EPL-AdPL			.3836	AbAL-FERAR	-.3186	AbAL-HDW
.4564	EPL-AdPR			.3995	AbAL-AbERAR	-.3621	AbAL-S.Years
.4840	EPL-EPR			.4311	AbAL-AdAL	-.4148	AbAL-Age
.5395	EPL-EAL			.4510	AbAL-FAR		
				.4715	AbAL-AbERAL		
.3076	EAL-IRAL	-.3177	EAL-Years	.7727	AbAL-AbPL		
.3235	EAL-FAL						
.3383	EAL-AdPR			.3045	AbERPR-GSR	-.3142	AbERPR-Years
.3911	EAL-FERAL			.3073	AbERPR-AbERAL	-.3250	AbERPR-BIW
.4215	EAL-AbERAR			.3198	AbERPR-ERAL	-.4328	AbERPR-GSL
.4559	EAL-AbERAL			.3239	AbERPR-ERPR	-.4779	AbERPR-RSFL
.4801	EAL-EAR			.3367	AbERPR-HDL	-.5599	AbERPR-GDL
				.3412	AbERPR-AbERPL		
.3026	AdPR-EAR	-.3171	AdPR-Train	.3626	AbERPR-FPR		
.3063	AdPR-FERPL	-.3410	AdPR-DAD	.3794	AbERPR-AbERAR		
.3071	AdPR-IRAR	-.4284	AdPR-Years	.3807	AbERPR-ERAR		
.3383	AdPR-EAL	-.5727	AdPR-ED	.3917	AbERPR-FAR		
.3440	AdPR-FAL			.4094	AbERPR-FERAR		
.4564	AdPR-EPL			.4118	AbERPR-EAR		
.4623	AdPR-AbERPL			.5062	AbERPR-FERPR		
.5354	AdPR-AdAL						
.5502	AdPR-AdPL			.3316	AbERAR-AdAR	-.3438	AbERAR-HDW
.7214	AdPR-AdAP			.3469	AbERAR-FERPR	-.3749	AbERAR-Train
				.3617	AbERAR-FPL	-.4009	AbERAR-Years
.3007	AdAR-AbERAL	-.3114	AdAR-Age	.3794	AbERAR-AbERPR	-.4932	AbERAR-S.Years
.3032	AdAR-EPL	-.3622	AdAR-ED	.3838	AbERAR-FERPL		
.3177	AdAR-AbAL			.3995	AbERAR-AbAL		
.3316	AdAR-AbERAR			.4215	AbERAR-AbERPL		
.4127	AdAR-FERAR			.4482	AbERAR-AbERPL		
.5198	AdAR-EPR			.5198	AbERAR-FERAL		
.7214	AdAR-AbPR			.5221	AbERAR-FAL		
.7898	AdAR-AbPL			.6128	AbERAR-EAR		
.8363	AdAR-AdAL			.6810	AbERAR-FERAR		
				.7406	AbERAR-FAR		
.7282	AdPL-EPR	-.3114	AdPL-AGE	.7612	AbERAR-AbERAL		
.3677	AdPL-EPL	-.3622	AdPL-ED				
.5502	AdPL-AdPR			.3063	AbERPL-EAL	-.3397	AbERPL-S.Years
.7898	AdPL-AdAP			.3227	AbERPL-AbPL	-.3770	AbERPL-Age
.8363	AdPL-AdAL			.3247	AbERPL-ERPR	-.3916	AbERPL-Years
.3599	AdPL-AbAL			.3247	AbERPL-FERPR		
.3227	AdPL-AbERPL			.3388	AbERPL-FPR		
				.3412	AbERPL-AbERPR		
.3059	AdAL-FERPR	-.3500	AdAL-ED	.4138	AbERPL-FPL		
.4311	AdAL-AbAL			.4475	AbERPL-FERPL		
.5089	AdAL-EPR			.4482	AbERPL-AbER?		
.5354	AdAL-AbPR			.4623	AbERPL-AdPR		
.7529	AdAL-AdAP			.6109	AbERPL-AbERAL		
.8363	AdAL-AdPL						

.3000	AbERAL-HDL	-.3019	AbERAL-GDL	.5173	FAL-EAR	-.4492	FAL-Train
.3007	AbERAL-ADAR	-.3277	AbERAL-S.Years	.3235	FAL-EAL	-.3410	FAL-FSBL
.3041	AbERAL-RSBR	-.3419	AbERAL-Train	.3440	FAL-AdPR		
.3073	AbERAL-AbERPR			.5221	FAL-AbERAR		
.3414	AbERAL-AdPR			.5357	FAL-AbERAL		
.3588	AbERAL-RSFR			.3604	FAL-FPR		
.3659	AbERAL-EAR			6332	FAL-FAR		
.4258	AbERAL-GDR			.4728	FAL-FPL		
.4430	AbERAL-GSR			.4105	FAL-FERPR		
.4559	AbERAL-EAL			.6080	FAL-FERAR		
.4715	AbERAL-AbAL			.4139	FAL-FERPL		
.5298	AbERAL-FERAR			.8089	FAL-FERAL		
.5357	AbERAL-FAL						
.5839	AbERAL-FAR			.4491	FERPR-ERPR	-.3311	FERPR-Years
.6109	AbERAL-AbERPL			.3770	FERPR-ERPL	-.4153	FERPR-BIW
.6350	AbERAL-FERAL			.4676	FERPR-ERAL	-.3323	FERPR-GSL
.7612	AbERAL-AbERAR			.3059	FERPR-AdAL		
				.5062	FERPR-AbERPR		
.3414	FPR-Flex	-.5355	FPR-BIW	.3469	FERP-AbERAR		
.5429	FPR-ERPR	-.3268	FPR-RSFL	.3247	FERPR-AbERPL		
.5523	FPR-ERAR			.7473	FERPR-FPR		
.5018	FPR-ERPL			.4785	FERPR-FAR		
.5527	FPR-ERAL			.6204	FERPR-FPL		
.3626	FPR-AbERPR			.4105	FERPR-FAL		
.3388	FPR-AbERPL			.4754	FERPR-FERAR		
.5269	FPR-FAR			.6658	FERPR-FERPL	.3189	FERP-FERAL
.7787	FPR-FPL						
.3604	FPR-FAL			.4803	FERAR-EAR	-.3319	FERAR-Years
.7473	FPR-FERPR			.4127	FERAR-AdAR		
.6088	FPR-FERPL			.3836	FERAR-AbAL		
				.4094	FER-AbERPR		
.3091	FAR-ERPR			.6810	FER-AbERPL		
.3863	FAR-ERAL			.5298	FER-AbERAL		
.3665	FAR-EAR			.7879	FERAR-FAR		
.4510	FAR-AbAL			.6080	FERAR-FAL		
.3917	FAR-AbERPR			.4754	FER-FERPR		
.7406	FAR-AbERAR			.3535	FER-FERPL		
.5839	FAR-AbERAL			.6224	FER-FERAL		
.5369	FAR-FPR			.5172	FERAR-GDR		
.4604	FAR-FPL			.4990	FERAR-GSR		
.6332	FAR-FAL			.3375	FERAR-RSFR		
.4785	FAR-FERPR						
.7879	FAR-FERAR			.3381	FERPL-EAR	-.3138	FERPL-BIW
.3618	FAR-FERPL			.3063	FERPL-AdPR	-.3590	FERPL-IRPR
.5689	FAR-FERAL			.3838	FER-AbERAR	-.4639	FERPL-IRPL
.3435	FAR-GDR			.4475	FER-AbERPL	-.3999	FERPL-IRAL
				.6088	FERPL-FPR		
.3617	FPL-AbERAR	-.3155	FPL-BIW	.3618	FERPL-FAR		
.4138	FPL-AbERPL			.7783	FERPL-FPL		
.7787	FPL-FPR			.4139	FERPL-FAL		
.4604	FPL-FAR			.6658	FERP-FERPR		
.4728	FPL-FAL			.3535	FERP-FERAR		
.6204	FPL-FERPR			.4304	FERP-FERAL		
.7783	FPL-FERPL						
.3395	FPL-FERAL						

.4116	FERAL-EAR	-.4466	FERAL-Train	.4719	HDL-S. Years		
.3911	FERAL-EAL			.3367	HDL-AbERPR		
.5198	FER-AbERAR			.3000	HDL-AbERAL		
.6350	FER-AbERPL			.3802	HDL-FERAL		
.5689	FERAL-FAR			.3520	HDL-ED		
.3395	FERAL-FPL			.3947	HDL-ADD		
.8089	FERAL-FAL			.7190	HDL-PRI		
.3189	FER-FERPR			.3617	HDL-HDW		
.6224	FER-FERAR						
.4304	FER-FERPL						
3278	FERAL-GDR						
.4092	FERAL-GSR						
.3802	FERAL-HDL						
.3553	ED-ERAR	-.4749	ED-IRPR				
.4261	ED-ADD	-.4215	ED-IRAR				
.5064	ED-DAD	-.5727	ED-AdPR				
.3112	ED-RSBL	-.3852	ED-AdAR				
.5805	ED-HDW	-.3622	ED-AdPL				
.3520	ED-HDL	-.3500	ED-AbAL				
.4424	ED-Pain S.						
.4261	ADD-ED	-.4215	ADD-ERPR				
.5420	ADD-DAD	-.4501	ADD-ERPL				
.4011	ADD-GDL	-.5282	ADD-ERAL				
.4542	ADD-PRI	-.3517	ADD-FPR				
.4777	ADD-HDP	-.3346	ADD-FAR				
.8652	ADD-HDW						
.3847	ADD-HDL						
.3638	DAD-BIW	-.3702	DAD-AdPR				
.5064	DAD-ED	-.3118	DAD-AbPL				
.5420	DAD-ADD	-.3405	DAD-AbAL				
.3898	DAD-HDP	-.3399	DAD-FPR				
.5984	DAD-HDW						
.3632	PRI-Years	-.3163	PRI-AbPL				
.3606	PRI-S.Years						
.4542	PRI-ADD						
.4524	PRI-HDP						
.5417	PRI-HDW						
.7190	PRI-HDL						
.5440	PRI-Pain T.						
.7266	PRI-Pain S.						
.5777	HDP-ADD						
.3898	HDP-DAD						
.4524	HDP-PRI						
.5483	HDP-HDW						
.8097	HDP-Pain T.						
.6419	HDP-Pain S.						
.5805	HDW-ED	-.3212	HDW-IRAR				
.8652	HDW-ADD	-.3101	HDW-AbPL				
.5984	HDW-DAD	-.3186	HDW-AbAL				
.5417	HDW-PRI	-.3438	HDW-AbERAR				
.5483	HDW-HDP						
.3617	HDW-HDL						

APPENDIX E
T-TESTS COMPARISON OF MODERATELY FLEXIBLE, MOST FLEXIBLE, LEAST FLEXIBLE AND LIMITS OF FLEXIBILITY GROUPS

MODERATE	MOST	SIG	MEASURE	MODERATE	LIMITS	SIG	MEASURE
55 deg	72 deg	.01	Ext Rot Pass	11 years	12 years	.05	Years
51 deg	66 deg	.01	Ext Rot Act	55 deg	63 deg	.05	Ext Rot Pass
30 deg	24 deg	.05	Int Rot Pas	51 deg	57 deg	.05	Ext Rot Act
53 deg	45 deg	.05	Abd Pass	53 deg	45 deg	.01	Abd Pass
132 deg	161 deg	.01	Flex Pas	47 deg	42 deg	.05	Abd Act
136 deg	162 deg	.01	Flex ER Pass	132 deg	145 deg	.01	Flex Pass
45	25	.05	ADD				
1.0	1.25	.01	PROM Score				
MODERATE	LEAST	SIG	MEASURE	MOST	LEAST	SIG	MEASURE
11 years	13 years	.01	Years	11 years	13 years	.05	Years
21 cm	23 cm	.01	BIW	1.3	1.8	.05	Training
30 deg	38 deg	.01	Int Rot Pas	63	50	.05	Flexibility
23 deg	31 deg	.01	Int Rot Act	20 cm	23 cm	.01	BIW
53 deg	46 deg	.01	Abd Pass	72 deg	54 deg	.01	Ext Rot Pass
47 deg	41 deg	.05	Abd Act	66 deg	50 deg	.01	Ext Rot Act
164 deg	151 deg	.01	Abd ER Pass	24 deg	38 deg	.01	Int Rot Pass
12	22	.05	PRI	21 deg	31 deh	.01	Int Rot Act
1.0	.76	.01	PROM Score	168 deg	151 deg	.01	Abd ER Pass
				161 deg	131 deg	.01	Flex Pass
				162 deg	130 deg	.01	Flex ER Pass
				2	1	.05	ED
				25	49	.05	ADD
				9	22	.05	PRI
				1.25	.76	.01	PROM Score
				1.1	.89	.05	AROM Score

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